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The American Society for Engineering Education

"Mr. Bell, I heard every word you said—distinctly!" Thus, on March 10, 1876, Alexander Graham Bell (left) learned that his invention had transmitted the first intelligible speech.

75 Years of Tomorrows

Like today's telephone, Alexander Graham Bell's invention came from research. For several years Bell had been investigating speech and hearing, devising methods and apparatus for electrical communication of intelligence. No one had sent speech sounds electrically but Bell saw that it must be possible —given the proper instruments.

One day, while experimenting with his harmonic telegraph, Bell's alert ear caught an unexpected sound in the receiver. His trained mind told him that here at last was the proof that sound waves could travel as their facsimile in electric waves. Then followed a year of development, and in 1876, as shown above, he transmitted the first intelligible speech by telephone.

During the next three-quarters of a century, the telephone research which Bell started has grown and expanded to serve your telephone system . . . often fruitfully overflowing into other fields of electrical communication. In today's Bell Telephone Laboratories, promising ideas find the right skills to bring them to life. Through skilled manufacturing by Western Electric Company and skilled operation by the telephone company they are brought to the service of the telephone user.

The high quality of your telephone today, its fine, swift service at reasonable cost, are the products of work in the telephone laboratories in the past. The greater value you may expect in the future is taking form there already.

BELL TELEPHONE LABORATORIES

Exploring and Inventing, Devising and Perfecting, for Continued Improvements and Economies in Telephone Service

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Professional Registration of Engineers

By N. W. DOUGHERTY

Dean of Engineering, The University of Tennessee and Chairman, Tennessee State Board of Architectural and Engineering Examiners

Introductory

Engineering registration is certification by the state that a practitioner has met at least the minimum educational and experience requirements set up by law to practice the engineering profession. The practitioner may be qualified far above the minimum but the state does not undertake to recognize degrees in qualification.

Registration gives legal status to the registrant. All persons are responsible for their acts but when the law has been passed, the responsibility may be quite different for those who are registered and those who are not. Unregistered persons may not collect professional fees; they may be liable for criminal negligence in case of disaster or they may be guilty of misdemeanor in case of ordinary practice.

During the period in which registration laws were being passed, many questions were raised as to legality, desirability from a professional point of view and feasibility of enforcement. Time has answered all these questions. The legality is based upon the police power of the state to protect life, health, safety and property. This is a very old power assumed by government almost as soon as government was organized and certainly assumed along with its power to protect itself. The state has a right to do anything necessary to protect itself and protect the lives of its people, the health of the people, their safety, and of course, to protect their property.

When the Constitution was written the states retained the police power for themselves and only gave the Federal Government such powers as were necessary for specific tasks; their own powers to protect their citizens were not changed or abridged. Almost the first question asked by the neophite is: "Why not pass a Federal law instead of all the state laws?" The reason has just been stated; the Federal Government was not given the needed police powers for this purpose.

The desirability of registration laws has been debated by engineers since the turn of the century. Always there have been two sides to the questions but the affirmative side has won. In the early days the opponents were the unqualified and the well qualified, while the proponents were usually the large group of engineers in between the extremes. The unqualified did not want to be left out; the well qualified were doing well without a law.

Some have said that registration was not feasible because of many bogie difficulties. Engineering could not be a profession because it had no relation of confidence; engineering covered such a wide range of activities that it was practically impossible to write a definition, and finally, if a law were passed it could not be enforced. Engineering does have a relation of confidence; it can be defined and the laws can be enforced. Laws have been passed in all the states, the District of Columbia and the territories of Hawaii, Puerto Rico and Alaska.

Demands Upon Education

Educators are interested in registration because all their graduates and many of their other students will practice in a world where registration is an accom-

plished fact. All the states have it. Slowly, but surely, registration is becoming a part of civil service procedures; it has already become a state requirement for engineering work and as a qualification for employment. Industry has begun to take notice of its meaning. Educators should have their say regarding the laws of the future. Medicine requires a minimum education for practice; the trend is toward engineering graduation for admission to engineering.

The doors are still wide open, and they should be, but the time is coming when a much stricter requirement for education will be a part of professional qualification. The road to engineering practice leads through the engineering college; tomorrow, or the next day, it will be through graduation.

Registration will have an effect on education; registered engineers are speaking their minds on the subject. More registered engineers will be introduced into the faculties. Registration had as much to do with ECPD accrediting as any other engineering agency. State Boards wanted to know the meaning of: "Graduation from a college satisfactory to the Board"; now they have a list of such colleges.

As engineers study education, they will become more vocal about it. They have something to offer; educators have something to offer in the conduct of the registration business.

Right now State Board examining procedures need your help in determining when a candidate is educated. Engineering practitioners on the boards have much faith in written examinations; you have been giving examinations all your professional careers and some of you do not have too much faith in them. You should help the engineers in your state to validate their examinations; they should not be an ordeal, but should be designed to determine qualification to practice engineering.

History of Registration

The government began to regulate medicine and in some cases, the practice of law, a long time ago. For example: Hammurabi had in his code a regulation for medical practitioners. The practitioner could operate on a believer but he must be right; if his patient died the practitioner was guilty of murder. The surgeon had three tries on an unbeliever and if they all died he had to quit the profession.

"Certain standards for admission to the medical profession have been recognized since the beginning of history. Even in ancient Rome the requirements were defined by legal action in an attempt to protect the public from practitioners who were considered not qualified to treat the sick. . . . From the beginning the object has been the protection of the public, not the protection of the physician."

Justin-Miller—
The Philosophy of Professional Licensure

The registration of engineers, however, is quite new. It began with the state of Wyoming in 1907 and extended to all of the forty-eight states by 1947. Montana, a neighbor of Wyoming, was the last of the forty-eight states to pass a registration law. Forty years of legislation were required to make registration universal.

The curve of enactment of laws shows that many factors had an influence on their passage. For example, legislation started in 1907 and gained ground slowly; then came World War I, which catapulted the engineer into the general civilization of the world and pointed to the fact that engineering activity is an important activity in any community. As a result, impetus was given to the registration movement. Many laws were passed between 1919 and 1928, then there was a slowing off; finally, the last law was passed in 1947, thus making a complete roll of all the states and territories.

During the whole period the technical societies were interested in the movement. At first they were against it, largely because the older members of the profession were in charge of the societies; then they became lukewarm, and finally, they joined in the movement. In the late teens the

engineers began to realize that the movement was gaining and that being nominally against it would not stop it. They prepared a Model Law and recommended it to the states. The societies did not recommend the passage of such a law but, if locally, the engineers insisted, here was what they should do. Many states did accept the Model Law as the desirable type of legislation. Others passed their own law to suit their own local ideas. Had the engineering societies come out for the movement as early as 1911, when the first Model Law was proposed, they would have had more influence on getting uniformity.

The next great series of improvements will probably come in uniformity of laws, uniformity of practice, and better enforcement. Another thing which will be essential is more universal application of registration to the profession. There are thousands of engineers in the United States who are exempted under provisions of the acts but who should be registered because they will ultimately undertake activities which are covered by state legislation.

Objectives of the Movement

What is all the shouting about? What were the engineers trying to do when they passed the first law in Wyoming? Water in that state was very important. In order to get water permits, someone had to file a map with the state showing the need of water and what the individual or organization was going to do with it. Maps were drawn by almost any person who could make a pencil sketch. As a result, there were conflicting claims and overlapping areas. Wyoming passed a law to be sure that the claims were reasonable and that the surveying was good. After the law was passed in 1907, the situation was cleared up immediately. This was a local situation and was solved in a local way.

Another example is on the Pacific Coast. The architects in California passed a law preempting certain structural activities to themselves. The engineers were being legislated out of a job in their field. They decided that the thing to do was to pass a law of their own in order that they might get back some of the structural activity which the architects were assuming. They passed the Structural Engineers Registration Law allowing engineers to design buildings and other engineering structures. This again was a local situation, but it did not continue to be local because the same problem arose in other states.

The object of Engineering Registration is to protect the public against incompetence; and incidentally, to protect the practitioner from incompetence. Practically all engineering activity has to do with some phase of public health and public safety; the design of a bridge, a water supply, a sanitary structure, a drainage structure, a machine, an airplane or an electric distribution system, all have to do with public safety and public health. If incompetent practitioners undertake work which engineers normally do, the public is involved and often put in jeopardy.

For the practitioner, the incompetent usually competes on a different level from the competent practitioner. He undertakes to do his work with the least amount of cost and as a consequence, he is willing to work at a lower price than the competent practitioner. One will prepare satisfactory plans and specifications, the other will try to get by. The general public is benefited, the practitioner is benefited because of the removal of the incompetent practitioner from his sphere of competition.

I like to think of the whole movement of registration as being a much larger thing than just the weeding out of the incompetent. It is part of the greater effort to get professional consciousness and professional recognition. During the last fifty years there has been an avalanche of joint activity to find a place in the sun. Engineers realize that their education is not ordinary education; it is in the category of professional and they are trying to find a place for them-

selves among the recognized professionals.

Registration places a badge on the initiate, it certifies that his friends think well of him; that he has had a minimum of education and experience; and that he is a beginning professional. These are important elements of the general problem of professional recognition.

The classification of "Engineer-in-Training" has been included in the Model Law for recent graduates and persons with limited engineering experience in order that they may identify themselves with the profession before they have achieved full professional status. Several of the states have included the classification and are using it for the training period between graduation and registration. In a recent paper Dr. Steinman, in American Engineer, lists the objectives of the engineer-in-training:

1. To give the young graduate professional identification and professional consciousness.
2. To start him on the road to professional qualification and recognition.
3. Through professional identification, to protect him from the inroads of unionization.
4. To facilitate relations of guidance, counsel, and cooperation by older engineers.
5. To expedite and facilitate the attainment of full professional certification.

One of the major objectives was to give professional affiliations in such a way that the beginner would be protected against having to join groups which were not to his liking. If the young engineer wishes to join groups of his own, that is his business, but he should not be forced into any organization against his will.

How It Works

Registration must be by the profession itself. The very nature of the license is such that only a person versed in the profession can determine those who are qualified. The state delegates to an engineering board the authority to set up rules for determining education, experience and responsibilty necessary to practice. The law is the general charter for their activities, and of course the Board must be fair and just, both to the public, and to the practitioner. The major object is to protect the public and not the practitioner.

Should the profession believe that it has a vested right to determine who should be admitted and thus arrogate unto itself unfair methods of determining qualification or discriminatory methods of issuing certificates the state would step in and rectify the matter. Should a profession try by law to fence in certain privileges for itself it will come to legislative grief. Examples of this type are the architects trying to preempt structures and lawyers trying to preempt writing deeds.

To operate the law, a renewal fee is necessary. This sets up a peculiar situation, that on December 31 a man is perfectly competent to practice and on January 1st he may be ineligible if he has failed to pay his fee. This is merely a legal technicality. He is just as competent, but to operate the law, the board must have funds and the state has said that the registrants must pay for the expense of the regulation.

Throughout the whole registration movement there has been difficulty with inter-state registration. Some of the laws provide that persons registered in other states, having requirements equivalent of their own, may be registered in the state on such evidence. We, in Tennessee, accept registrants from other states because our law allows us to do so. Some states make it quite difficult for a person to transfer from another state to their state. The National Council of State Boards of Engineering Examiners has done good work; it has set up a registration bureau, which investigates records, statements of experience, education, and finally, certifies its findings to all state boards. Many of the boards can use the

certificate as competent evidence of qualification; others can use it as additional evidence; and finally, a few states do not accept the National Council certificate at all. The National Council, of course, has no authority to register anyone; registration is a state authority and cannot be delegated to any national council.

Results of Registration

What has been achieved by Engineering Registration? First, certain local problems have been solved, as for example, the Wyoming and California problems and other similar problems which have developed in other states. There has been a great growth towards unity in the profession. Registration has had its part; it may not have been the prime mover in the unity but at least it is one activity in which all engineers may engage. They can take an active part in seeing that only competent persons are registered and seeing that only competent practitioners are in the field.

Those of us who have been in the movement believe that we have better public understanding. The state has recognized the profession as having legal status. As a result, the people in the state understand better the difference between a professional and a non-professional. Of course, this same objective is being promoted by the Technical Societies and the National Societies throughout the states and through their local branches.

It has set up a definition of professional status—graduation plus four years experience—or eight years experience with an examination. This type of qualification is becoming the minimum for recognition of professional status. The National Technical Societies have before them now, the recommendation of ECPD to make this requirement the minimum for membership in a society. If the societies adopt the same nomenclature and the same requirements for grades of membership, their titles will mean the same throughout their membership and they will have the same requirement as the State Examining Boards.

There has been a strong incentive for self improvement in borderline cases. Written examinations have been required. There have been a number of repeaters who finally passed the examination. This has meant home study, extension courses, and coaching to get an improvement in their educational background. Certainly the competent have not been injured and the beginners have been improved.

The movement has swept the whole country. It began in Wyoming and ended in the adjacent state of Montana; all the other states having passed laws during the period. We are no longer in the beginning of the registration movement but probably nearing its noontide. The next great step, as I have said before, will be to improve the registration laws, to get better enforcement; to make the laws apply to all practicing engineers and to make it easier for engineers to pass from state to state.

Signs of Our Times*

By HAROLD E. WESSMAN

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What are the signs of our times, which, reflecting the experience of the past and the achievements of the present, point the way toward distant horizons? What do the signs of our times suggest as to the world of tomorrow?

The historian would have one answer to these questions. The philosopher another. The sociologist still another. How would the engineer or the scientist answer such questions? It is an intriguing occupation to journey beyond the horizon and visualize the scene twenty-five or fifty years hence. In fact, it is almost impossible to seek the answer to some immediate engineering problem without keeping one's eyes on distant horizons. Every research worker in accepting and meeting the challenge to fill a gap in our knowledge has seen the boundary of that knowledge move farther and farther away as he learned and discovered more and more.

There has never been a fixed frontier in science and technology. Every new development has pushed the frontier farther and farther toward the infinite. We may think we see the horizon line for the immediate present, but if the lessons of the past have any meaning whatsoever for us, we know that beyond that horizon lies another and another and yet another. No surveyor of the finite universe will ever be able to stake out the horizon line, write a legal description of it, and file it away in the county recorder's office for posterity.

What lies beyond the horizon? What will the world be like in 2000 A.D.? What will man be like? His religion, his society, his economics, his politics? Where will the advance guard of science rest? How far will the main body of technology have progressed? How will life be affected by the constantly accelerating impact of science and technology?

Yes, it is fascinating to let your mind wander into that land beyond the horizon, whether you be scientist, engineer, philosopher, economist, or poet.

"For I dipt into the future, far as human eye could see,
Saw the Vision of the world, and all the wonder that would be;

Saw the heavens fill with commerce, argosies of magic sails,
Pilots of the purple twilight, dropping down with costly bales;"

Lord Tennyson, in meditation more than 100 years ago "with the fairy tales of science, and the long result of time," thus brings to us his dream of the coming air age. It was sheer fantasy at the period when Tennyson wrote "Locksley Hall," but we know it as accomplished fact of today.

Others, before and since Tennyson, have attempted to lift the veil which hides the future from the present. Forty years ago H. G. Wells wrote his excursion into the 22nd Century, "The Sleeper Awakes." His descriptions of radio, television, and aeroplanes written at a time when no one of these existed were amazing and unbelievable. Viewed in the light of current developments in these fields, we realize how amateurish were his conceptions in his earlier writings. Instead of

* Presented before Civil Engineering Division, ASEE, June, 1950.

waiting 200 years for the fulfillment, science and engineering, in the short span of 40 years, have brought the aeroplane and radio to a point far beyond that which Wells, even with his vivid imagination, could visualize.

Edward Bellamy in "Looking Backward" moved his main character, Julian West, forward only 113 years from 1887 to 2000 A.D. and by this device gave us a look at Boston 50 years hence. Bellamy's Utopian dream, which seems to have overlooked the nature of human nature, does not take one on the detailed engineering excursions which characterized the Wellsian dreams. Nevertheless, he portrays a new Boston, one which is extremely pleasant to contemplate.

In the Limit

Yes, it is fascinating to journey "beyond the horizon," but if you wish a pleasant voyage, do not travel to the end of time, billions of years hence, when according to the astronomers, all processes of nature will cease. Lincoln Barnett in his recent book, "The Universe and Dr. Einstein," encourages us to a non-productive existence during our short stay in this world by stating, "All the phenomena of nature, visible and invisible, within the atom and in outer space, indicate that the substance and energy of the universe are inexorably diffusing like vapor through the insatiable void. The sun is slowly but surely burning out, the stars are dying embers, and everywhere in the cosmos heat is turning to cold, matter is dissolving into radiation, and energy is being dissipated into empty space. . . . There will be no light, no life, no warmth —nothing but perpetual and irrevocable stagnation. And there is no way of avoiding this destiny. For the laws of nature—and in particular the fateful principle known as the Second Law of Thermodynamics—assert that the fundamental processes of the universe are irreversible."

When we contemplate that uncomfortable ending in store for this universe, it is only natural for us to ask the astronomer-scientist, "But can you prove that there will not be another universe?" I am not a theologian, but I do have enough faith in life eternal to say to the unborn generations billions of years hence, "Cheer up! There was an Origin, a Creation, call it what you will, of this universe in which we now live. I am sure that there will be another Creation and another universe for you and that Life in your age will be even richer and more beautiful than Life is today."

There are those who would take issue with that statement. They are those who say that civilization with its wars, its problems of today, moves backward rather than forward. They point to the Golden Age of Literature, to the glories of ancient Rome and Greece, to that high level of intellectual culture which characterized the citizens of Athens five centuries before Christ, and they cry, "Let us go back to the good old days." To them I would say, "Take an excursion with the Connecticut Yankee to King Arthur's Court, or for that matter, travel with Peter Standish of Berkeley Square, London, from the year 1928 to the year 1784—to an England saturated with disease, cruelty, and indescribable filth, an England so smelly that Peter Standish in a dramatic climax exclaims, "God, how the Eighteenth Century stinks!"

One does not have to be a sanitary engineer to appreciate the march of progress in removing the stench which pervaded the atmosphere of the cities and towns of our forefathers. I am certain that he who yearns for past glories would, if transported to that day and age, soon want to come back to his electric lights, his refrigerator, his radio, his automobile, and his bath. Yet, he would soon wish to return to this age of science and technology where the lot of the common man with all his trials and tribulations is infinitely better than that of 100 years ago —to this day in the United States of America when the common man not only

has time for philosophical contemplation, but what is infinitely more important, the chance to become an uncommon man. And it is no coincidence that it is here in our America under a system of private ownership and free enterprise that science and technology have made the greatest strides, and that the average man enjoys the highest standard of living in the world.

The Pinnacles of Research

What are some of the outstanding research developments during the past decade in various fields of engineering, developments that will have a profound influence on the world of tomorrow? To get the answer to that question I consulted a number of my engineering friends in different universities. The following $64 question was presented to them: "What do you consider the three most significant research developments in your field during the past ten years?"

As one might expect, there were differences of opinion, but nevertheless there was enough agreement to focus attention on certain achievements in each major field. Radar, television, servo-mechanisms, and electronic computers highlighted the realm of electrical engineering. Synthetic rubber, fuels, and the recovery of magnesium from sea water stood out in chemical engineering. The aeronautical engineers believed that the flight of man at supersonic speeds was the most remarkable achievement in recent years, but they noted that this rests upon a host of research studies in aerodynamics, in aircraft structures, and in aeroplane power plants. The mechanical engineers listed jet engines, rocket engines, and stress analysis of metal parts subject to high speed and high temperatures. Civil engineers listed research on airport pavements, super-highways, reinforced-concrete slabs, aerodynamic studies of suspension bridges, and filter processes in sewage disposal. The metallurgical engineers listed high-strength steels and aluminum and magnesium alloys, and the ceramic engineer pointed to studies in high heat-resistant refractory linings.

Almost every engineer mentioned nuclear fission, not so much in terms of the amazing discoveries of the physicists, but rather in terms of the engineering research, the industrial super-marvels in a host of related fields which were necessary to bring into successful operation the stupendous plants at Oak Ridge and at Hanford and the bomb assembly plant at Los Alamos.

Each of the developments noted is a story in itself. Moreover, each is the result of a chain of basic research studies which in some cases extends years into the past.

The development of radar, in other words, radio detection and ranging, is one of the fascinating stories of intense scientific concentration during the war. But though the development of radar is definitely associated with the war, it is a combination of various elements, all of which had their origin in earlier days. The radio-physicist, Heinrich Hertz, in 1887, made the first discovery that radio waves were reflected from objects like light rays, and the second discovery that radio waves could be directed along narrow beams. The third discovery was that distance may be measured accurately by timing the high-speed travel of the radio wave. The fourth was that reflected waves may be detected by wave interference patterns. The fifth was the principle of radio-pulse ranging. Fitting these building blocks together and developing the necessary instrumentation, such as the pulsed microwave magnitron for measuring accurately very short intervals of time, were the ultimate achievements.

We all know how radar saved Great Britain during the war, how Japanese warships were sunk in total darkness by radar-equipped American ships, but the peacetime uses of radar in navigation and in such spectacular applications as ground-controlled plane landings in dense fog with zero ceilings, or in weather fore-

casting are just beginning to attract the attention of laymen.

The amazing developments in the field of nuclear energy which reached fruition during the past decade also had their origins years ago, but in 1905, when Einstein published in a German journal the now world-famous equation which gives the relation between energy and mass, $E = MC^2$, not even he foresaw the train of events leading to that crucial date, December 2, 1942, when the physicist Enrico Fermi finally achieved success in starting a sustained chain reaction and in controlling it in his uranium and graphite pile beneath the concrete bleachers at the University of Chicago.

There were still many problems to be solved after this historical date, but most of them were engineering problems. The successful solution of these problems for war-time purposes culminated in that awesome atomic bomb explosion on July 16, 1945 at Alamagordo, New Mexico. The culmination for such major peacetime purposes as the generation of power from nuclear energy is still in the future, but possibly in the very near future. Experimental power plants will soon be in operation at two laboratories. Concurrently, research has been started on the difficult problem of the disposal of radio-active wastes. This is one of the most challenging researches ever to confront the sanitary engineer.

Man's new knowledge of the atom has brought the world to the threshold of a new era. It has opened up new vistas of research undreamed of 10 years ago, research touching almost every phase of scientific activity. It has highlighted the need for a new kind of engineer—the nuclear engineer. The basic pattern of training for such an engineer is not yet clearly defined, but it will undoubtedly call for graduate study in nuclear physics, superimposed on a fundamental education in science and technology.

It is hardly necessary to focus attention on the complex problems posed for the economist, the sociologist, and the political scientist by the development of atomic energy, a development which must of necessity be under the control of the state. Nuclear fission is "Too hot"; it has too many national and international ramifications to be entrusted to private enterprise. That is why its development has been placed under the control of a Federal Agency, the Atomic Energy Commission.

Transportation and Communication

What lies "beyond the horizon" in the realm of transportation due to the significant developments of the past decade? Only 45 years ago the Wright Brothers left the ground at Kittyhawk in the first successful flight through the air. They flew 120 feet, 10 feet above the ground, at 30 miles per hour. No airport was needed. Two years ago, the Boeing XB-47 Stratojet swept-wing bomber flew from Moses Lake in the State of Washington to Washington, D. C., in a little more than 4 hours at a speed greater than 600 miles per hour. It would never have left the ground, however, without the modern air strip designed by the civil engineer. Other planes have pierced the sonic barrier and now fly faster than the speed of sound and at heights over 50,000 feet above the ground. The V-2 rocket reached an altitude of 114 miles. It streaked through the sky at a speed of over 2000 miles per hour to drop its lethal load of TNT on London. A new Navy rocket has just risen to a point 250 miles above the level of the earth. Is it any wonder that engineers and scientists are talking about rockets to the moon? With rocket engines which do not need air for fuel, with nuclear energy as a source of power, with metals of high strength, with refractory linings of high heat-resistance, with radar as the navigation and communications aid, travel to the moon, 238,000 miles away, does not seem to be a fantastic dream.

Less spectacular in nature will be the terrestrial expansion of superhighways to make our automobile travel safer, faster,

more economical, and more convenient. Billions of dollars will be spent in the next 25 years modernizing the existing 3,000,000 mile network of city and county roads and in creating new transcontinental routes. There will not only be divided lanes, there will also be separate routes reserved solely for passenger cars, traveling between the great metropolitan centers in the densely populated sections of the country. There will be new pavement types.

The field of servo-mechanisms and electronic controls is one that will affect the lives of many of us in future years. Industrial application of servo-mechanisms is still in its infancy, but nevertheless we are already sensing the implications in the development of numerous automatic machines with a concomitant displacement of labor. The resulting social problems are serious, but we must not forget that science and technology, while reducing the labor rolls on one front, are constantly creating new jobs on another front.

Television is a typical example. It has already become an industry of major proportions, offering employment to thousands of people. At the beginning of 1950, 98 stations were broadcasting television programs to about 3,700,000 receiving sets. Sets are now being turned out at the rate of more than a million a year.

What will be the effect of television on education, on movies and drama, on sports, and on the living habits of the nation? At present, there is some belief that television is doing more harm than good. Too many oldsters are spending too much time in front of saloon and tavern receivers; too many youngsters are camping in front of home sets when they should be outside playing baseball and football.

In the realm of education, television is certain to exert a growing influence in coming years. In medical education, the operating theater filled with eager medical students is on its way out, for television now lets every student stand in the center of the stage and look over the surgeon's shoulder at the intricate sequence of a difficult operation.

Electronic computors, digital and analog, are now providing answers to problems hitherto unsoluble in stress analysis, in astronomy, in electrical networks, in mechanical vibrations, in ballistics research. They are being used to explain the behavior of electrons, protons, and neutrons. They are accomplishing in minutes what formerly would have required hundreds of man-years of work with desk calculators.

Will the world of tomorrow be a time-and-motion study world? Will we all button our vests from the bottom up, instead of from the top down, because Frank Gilbreth found that four seconds could be saved. Will we all use two shaving brushes concurrently to save 17 seconds? Will we all take our baths in precisely the same way? It is easy to lampoon the results which Dr. Gilbreth and his equally famous wife, Lillian Gilbreth, have obtained, but we know that their studies and similar researches have lightened the work load for thousands of people in industry. The techniques of this science are now being extended to the field of agriculture, and in the future our farmers will do as much and even more than they are doing today and with much less effort.

Housing is due for a major operation. A substantial, low-cost home that will conform to minimum accepted standards and will have somewhat more individuality than a dog-kennel is the crying need of today. The satisfactory ones are still too expensive. The low-cost ones are too cheap. According to the Twentieth Century Fund Survey, about 15,000,000 new houses will be needed in America by 1960. About 9,000,000 of these are replacements of existing sub-standard, urban and farm dwellings.

The housing needs of America and the world will never be met, however, if we continue to build the majority of houses

in the future in essentially the same way that they were built 30 years ago. We cannot ignore the lessons of other achievements as to the relative values and roles of human energy, animal energy, and mineral energy, yes, even nuclear energy. Machine-age production of artistic homes is on the way. Current and future research, plus the competitive urge inherent in the political and social climate of this country will find the answer to this major problem of low-cost, satisfactory housing.

One could go on indefinitely looking through the rose-colored glasses of science and technology at distant frontiers. But one detects the note of the cynic, "Why don't engineers and scientists take a long vacation? What price glory if it means only the winning of more material comfort for mankind. Is it all worthwhile?"

Of course it's worthwhile! The research engineer and the scientist will never stop. They, like all research workers—in fact, like all human beings—respond inherently to a challenge. They, like all research workers, will continue to accept the challenge that urges them upward and forward on trails that disappear beyond the horizon. They are aware that their achievements will bring to the fore complex social, economic, political, and spiritual problems. But the engineer and the scientist cannot be expected to solve these problems. They must relinquish them to kindred spirits in sociology, economics, political science and law—to experts who will have an appreciation for, and some knowledge of, the nature of science and technology as they seek the answers to these very difficult problems dealing with human nature and behavior.

We all travel together on the trail that has no end—and as we journey together with eyes fixed on distant horizons, let us remember these lines,

He builds his temple on the shifting sands
Who holds no toil worn hand within his own
A portless mariner by fate's wind blown
He wrecks his ship on failure's deadly land.

Who has not high ideals at his command
Knows not creation's joys nor can enthrone
The mind's high majesty, but walks alone
Nor feels the rapture born of work's demand.

Then do the thing which life ordains for thee
For its own sake, and set thy spirit free
From all that holds thee to the lesser thought.
Make of thy task a shrine, and kneeling there
Lift to thine eyes the things thy hand hath wrought,
And in thy soul breathe deep achievement's air.

—Anonymous

Factors and Trends Relating to The Economics of River Developments*

By MERLE E. SUTTON

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It is with somewhat mixed feelings that I address you on the subject of River Development. This stems from the fact that, as counselors and advisers to the younger generation of engineers you can and do prepare them for the important decisions which they are to make in the future, and secondly, as engineers you are obviously interested in details and current thoughts pertaining to water resources and their control.

In view of this observation and the limited time available, it seems best to approach the subject from the standpoint of relating the broad factors involved with the hope that the stimuli of discussion and questions raised would be of equal value to the citation of specific problems and their solution. That is to say that "where we are going" is of equal or perhaps more importance than "where we have been."

We all appreciate the fact that natural rivers and waterways are God-given resources which have played an important part in the growth and development of our country. It may also be added, as we will discuss later, these same rivers, by the whims of nature, have produced some of our most aggravating economic problems. Even while many of our larger urban and rural areas have outgrown their early dependence upon the waterways for communication and commerce, their continued growth and prosperity are monuments to the part these waterways have contributed and still do contribute to this growth. This economic status has not been attained without a price having been paid in the form of flood damages. A continuing battle has been waged to prevent these damages and to promote a profit by commerce through navigation on our inland waterways. The benefits have justified the price, but economic complexities have brought into being the modern and concentrated versions of river development.

While this paper has to do with the Economics of River Developments, it cannot hope to discuss in detail all the interrelationships of river development useful to the young engineer, nor can it completely review the scope of all problems associated therewith. However, we can touch upon some of the general aspects of the problem which will aid in keeping our thinking straight. Likewise, a review of recent directive trends in regional river development will indicate some of the economic factors and problems requiring solution and perhaps in so doing will assist in establishing constructive suggestions for the benefit of our over-all economy.

The tools of economic analysis have been variously and quite completely covered in papers and texts available to the engineer and student. What we may not see so clearly, however, are the problems and trends which will require the skillful use of these tools. Then our first attempt should be to establish a theme, less specific in nature than the technical aspects

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of the problem, in order to introduce the approach we wish to make. This theme is the human side of engineering—that intangible but real something that makes for leadership and accomplishes the ultimate element in professional service.

The Engineer's Responsibility

It is not enough that the young engineering graduate be armed with a complete set of classic fundamentals which he may polish to varying degrees of brilliance in fields of practical application. His responsibility goes farther and his eventual success depends upon the manner in which the human factors find a place in his equations.

The very nature of the engineer's creative effort involves the welfare and inherent rights of people which must, therefore, be recognized in all situations where these factors exist. In fact, because the results of his efforts affect people in some manner or other and his success is dependent upon how well they are served and made to understand it, the engineer must be able to transmit his thoughts and ideas in common and straightforward terms. He must always be conscious of the resultant social and economic impacts of his work and be guided accordingly. To be sure, the engineer can develop the facility to cope with problems of this nature only after long experience, but the sooner he learns that to do so is a requirement of his profession, the greater will be his value to society. He will also be a happier and more successful man than if he remains a technological hermit and witnesses the products of his creation gravitate into inflexible patterns not subject to or amenable to the greatest good.

Now back to our primary subject. Rivers have not always been obedient servants; they have been unruly in flood, overrunning their banks and dispoiling rich cities and adjacent lands while whimsically changing their channels or filling them with navigational hazards. In other areas, people also have become dependent upon river waters to irrigate the fertile but semi-arid lands isolated by nature. As the National economy expanded, the problems of flood control, navigation, irrigation and industrial power also increased. This is not to say that they did not exist before, but, rather, that they have become more complicated with time; thus affecting the rights and lives of greater numbers of people.

The initial solutions to river problems were largely on a single purpose basis, as for example in regard to flood control, by the building of levees on the Mississippi River and the early flood control dams in Ohio. Perhaps flood control did not mean much to a New England coastal community or to the people who lived along the Florida beaches, for example, but when the rainfall in the Mid-west and the melting snows from the eastern and western mountain chains rose coincidentally in the Mississippi River until the water lapped the tops of the levees, flood control became a reality, and when the levees failed, a tragedy. As the obvious solution to flood control became that of controlling the source—the tributaries—an extension of National responsibility evolved. And so it has been with the other basic problems, such as navigation and irrigation, until now we have the multi-purpose projects in regional river basin development. This is not to say that each project is justified on the basis of navigation, flood control or irrigation, but rather that each regional development may contain projects justified by one or more of these elements. Truly then the National Government, by virtue of its responsibilities, has been placed in a position to develop a great river basin; for navigation, flood control and irrigation are all part of the problem.

We cannot question the evolutionary processes by which this situation has been brought into being, but because the economic development of river resources is essential to National and regional economies the costs of these developments must be paid in one manner or another. Project feasibilities must be supported by

the tangible and intangible economic factors associated therewith and be related one to the other in proportion to the importance ascribed to each. If this be true, and while in itself not providing an inclusive formula for the allocation of project costs to the beneficiary elements, it will at least focus our attention on a starting point. Strictly speaking, each element should be able to stand on its own economic merits within the over-all project justification and bear the spotlight of careful business cost analysis or accountability.

Conflicting Theories of Cost Allocation

Without sound and valid starting points as to the economic factors involved, conflicting interests cannot effectively cooperate to the end that maximum mutual benefits be attained. The problems and economics of river development are not simple nor are they the same in all regions. There can be no positive or definite pattern in connection with a determination of the economics involved in river development because conditions and requirements are not necessarily static nor similar and thus variations must be carefully compromised. Therefore, it is erroneous to assume the same yardstick as applicable in all cases. If this be a valid assumption, then the administration or coordination of a regional development must be sensitive to and largely subordinate to regional requirements. Apparently then, responsibility in river basin development and the multi-purpose projects contained therein is a cooperative partnership; the National Government representing the National interests and the region representing those which are or may become of regional significance and importance.

To the east, the south, the north and to the west the evolutionary process of river development has proceeded—each having its peculiar problems with honest attempts being made to solve each problem in its own particular way. Objectively, this is as it should be. The engineer must be ever conscious of this fact; he must be able to discern those interests or factors which are specific and those which may be in conflict or overlapping and advise accordingly.

We have progressed to considerable lengths in river development from the time in which power generation was considered solely an incident by-product to hydraulic projects, to the present in which power generation has become of major importance in such projects. Hydro-electric power, a younger brother of the multi-purpose project and necessarily a product of regional river development, has assumed robust and dominant proportions and must be treated with a respect compatible with its importance. It should also be apparent that most of the hydro-electric energy generated in the future must be from river basin development, as it is inseparably connected with water conservation for all purposes.

In its role of developing river basins to meet navigation, flood and irrigation requirements, the National Government has largely assumed the control of power resources incident thereto. Perhaps this evolutionary process would be more logical if it were not for the fact that Federal administrative agencies oftentimes reflect marked differences in perspective and objectives. Variations in viewpoint and, when coupled with the importance that electric power plays in regional economies, pose critical problems, solutions to which must be found. Let us look at a few of the more general cases.

In the construction of Boulder Dam (Hoover Dam) and the power lines leading to the City of Los Angeles and elsewhere, the financing was so arranged that Los Angeles and other customers of the Boulder Dam system guaranteed repayment, with interest, of the sums expended by the Government for construction. Of course, the people of Los Angeles therefore believe that all publicly owned power projects, wherever built on any of our rivers, should be financed in similar fashion and should be designed

to pay interest on the investment until it has been completely amortized out of plant income.

An entirely different situation exists where dams are built by the Reclamation Bureau for the primary purpose of irrigation and flood control. Power may in some cases be sold at such a price as will permit paying interest on the sums expended for construction of facilities, but the interest goes to assist farmers in the area reclaimed to pay the bill for irrigation and other charges. These dams are of benefit to the areas they serve, both in providing low electric rates and in aiding agriculture, but the money paid in interest subsidizes the farmer. Moreover, the feasibility of the irrigation element is distorted in this type of multi-purpose project.

A typical basin development is the Tennessee Valley in which the Government has built a series of dams for power, flood control and navigation. Federally owned dams and transmission lines provide power to municipalities and cooperatives for distribution. The locally owned distribution systems finance their operations on a self-sustaining basis and pay power rates sufficient to pay T.V.A.'s cost for that part of the expenditure allocated to power, with sufficient margins to pay to the Government the equivalent of interest, certain taxes and to amortize the debt.

A fourth procedure is that where the U. S. Engineers build power plants as a part of river improvement for flood control and navigation.

There seems to be a multitude of variations to these main ideas, and it may be that all of these various arrangements have merit and are justified. Perhaps they are all equitable and each procedure, as is very probable, best adapted to the needs and conditions of the area served. Certainly, if some region in the country is short of water power resources and must, of necessity, produce its electric energy by other means, this would not be a good reason to deny the development of other regions containing river resources. If these water resources are usable and the plan is feasible, there is no reason why they should not be utilized. But, whatever the project—large or small—it should not be for the profit of one section at the expense of the rest of the nation. On the contrary, it should be so developed as to be economical and profitable to the nation as a whole.

Developing of Sound Principles

If there are inequities or injustices, in fairness to all, they should be corrected and only through a strong partnership representing both Federal and regional interests can these problems be searched out and solved. In this concept will reside the basis and assurance of sound planning and the proper evaluation of the economic factors associated with river development to the end that valid justifications need never be questioned. To be successful, something more than formalized public hearings will be required. Rather, it must be a hard-hitting working arrangement capable of making decisions without prejudice to business principles.

Such questions as how should the allocation of costs for flood control, irrigation, navigation and electric power in multi-purpose projects be made so that financing and amortizing of the investment and the costs of operating the facilities will be on a self-liquidating and sustaining basis are not simple. But the fact that it is more economical to serve multi-interests in a common project by no means makes it impossible to determine the share of each in the project. It would be far more difficult to justify the position that the consumers of electric power for example, by their purchases through their own public agencies, are not entitled to the generating and transmission facilities once they have paid the Government in full. This is not a new point of view and its importance will increase with time.

While considerable emphasis has been placed upon Federal river basin development because of its evolutionary and dominant position, regional concern and voice must be representative of both private and public interests involved. This cooperative obligation has been brought into particular prominance by the importance of electric power generation and the desirability of integrating output and transmission through interconnections and power pools. While this example of regional cooperation between Federal, public and private utilities is one of operational procedure and is very advantageous to all parties in obtaining the maximum benefits of generation, it should also focus our attention on the necessity for similar integrated water development.

Complete river basin development implies full and effective utilization of all water resources and because the development boundaries are readily determinable and fall within limits, each successive planned step must recognize the ultimate need. The crux of this statement lies not in the fact, which is appreciated by most of us, but in the trends which may place its accomplishment outside the control of those most intimately affected. Whether water resources are being developed by the National Government, by private enterprise, by States or by lesser public agencies coordinated accomplishment can and must be attained through cooperation—representative cooperation—to assure that all plans and programs are productive of the greatest good and free from dominance.

Let us be certain then that the waters stored in common reservoirs for flood control, irrigation, navigation and power be charged for in proportion to their occupation and use of facilities with annual charges thereafter measured by the bentfits to each. Let us recognize that while the National Government must continue to play an important and perhaps leading part in river basin development, this mission must be accomplished in cooperation with other regional programs and needs without dominance. Then wishful justifications will be out, projects will bear evidence of economic feasibility, and, lastly, peace should reign on the question of what should be done and how it should be done in river basin development.

ANNUAL MEETING

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"Packaged" Unit Operations Laboratory Equipment

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Summary

A survey of manufacturers and special fabricators was made to determine the availability of "packaged" type unit operations laboratory equipment for use especially in educational institutions. The conventional unit operations laboratory apparatus can be obtained as "packaged" units from the suppliers listed. The more specialized equipment can be procured at higher cost from various manufacturers and special fabricators, some of whom also are listed.

Introduction

Several educational institutions recently have had to purchase unit operations laboratory equipment for new experiments, or to replace that which was worn-out, obsolete, or destroyed. When the number of pieces of new equipment is large, a great deal of staff effort is required for its selection, specification and location of suppliers. As is too often the case, staff members are already working at full capacity and this additional burden presents a serious problem.

General

In order that other staff members faced with the above problem can reduce the work required to locate suitable laboratory equipment, the authors report the result of their survey of the suppliers of "packaged" type unit operations laboratory equipment. It might be well to explain what is meant by a "packaged" unit. Such a unit is defined as a piece of equipment which is ready for operation when connected to the various services; that is electricity, steam, hot or cold water, air, vacuum or drain. If the "packaged" unit is large, it will require reassembly before connection to the services.

The authors have endeavored to include only those units which in their opinion are adaptable to small scale laboratory work. A rather large number of these small "packaged" units are available for the more important unit operations. These require no engineering design on the part of the customer. They are grouped conveniently, according to the unit operation, in the charts which appear with this article. Some manufacturers will fabricate "packaged" units to the customer's specifications. This information is also given in chart form. Extensively detailed information about each unit was purposely omitted in fairness to those manufacturers who did not submit such complete specifications of their equipment. Since the overall dimensions are of vital interest, they are included in most of the charts; some of these are estimates.

Packaged Units

Distillation: Distillation outweighs any of the other unit operations in importance and extent of use. "Packaged" units to perform all types of distillation are available in a wide range of sizes, materials of construction, and prices.

Most of these units are provided with sufficient instrumentation to make them

*Now at Oak Ridge National Laboratories, Oak Ridge, Tennessee.

readily adaptable to laboratory experiments. Several are available with packed columns but the majority of the columns are plate types containing from 15 to 30 bubblecap trays. In general these units may be operated under a vacuum or at moderate pressures. Units are also available for operation at higher pressures. As a rule, manufacturers are prepared to make slight alterations in design to conform to the customer's need. The extent of these alterations, of course, will determine the increase in price above that of a "packaged" unit. Prices range from about $500 for a simple batch unit of copper construction to approximately $10,000 for the most elaborate plate column, also of copper construction. Table I contains the summarized list of manufacturers of distillation units.

Evaporation: Equally as plentiful and versatile as the number of distillation units are the "packaged" evaporator units. Single-, double- or triple-effect evaporators may be purchased at prices ranging from $650 for a Pyrex glass single-effect bench model unit to $11,000 for a large triple-effect unit of steel construction. A versatile double-effect evaporator is pictured in Fig. 1. This evapora-

TABLE I

MANUFACTURERS OF DISTILLATION UNITS

Manufacturer and Address	Column Dimensions		Col. Diam.	Versatility of Operation	Materials of Construction
	Plates	Overall Ht.			
Acme Coppersmithing & Machine Co. Oreland, Penna.	20	30'6"	14"	Simple batch distillation, batch and continuous fractionation units. Fractionation unit	Copper
American Copper & Brass Works 612 E. Front St. Cincinnati, Ohio	17	20'0"	8"	Fractionation unit	Copper
Ansonia Copper & Iron Works Cincinnati 4, Ohio	20	15'0"	4"	Simple batch distillation, batch and continuous fractionation unit.	St. S.
	20	14'0"	8"	Fractionation unit	St. S.
	30	12'0"	3"	Fractionation unit	St. S.
Arthur D. Little, Inc. Cambridge, Mass.				Recompression still	
Artisan Metal Products Co. 73 Pond St. Waltham 54, Mass.				Packed column Fractionation unit	St. S. St. S.
Badger Mfg. Co. 260 Bent St. Cambridge, Mass.	15	24'0"	8"	Simple batch distillation, batch and continuous fractionation unit	Copper
Brighton Copper Wks, Inc. Cincinnati, Ohio	20	20'0"	8"	Fractionation unit Simple batch distillation	Copper St. S.

TABLE I—*Continued*

Manufacturer and Address	Column Dimensions		Col. Diam.	Versatility of Operation	Materials of Construction
	Plates	Overall Ht.			
Carter & Nansen Co., Inc. 415 Lexington Ave. New York 17, N. Y.	20	22′0″	12″	Simple batch distillation, batch and continuous fractionation unit	Copper
Cleveland Coppersmithing Works 5500 Stone Ave., N.W. Cleveland, Ohio				30 gal. batch still	St. S.
Emerson Sheuring Martindale Ave. & 21st Indianapolis 7, Ind.					
Pfaudler Co. 111 W. Washington Ave. Chicago 2, Ill.		10′	4″	Packed column fractionation unit 30 gal. simple batch distillation unit	Glass lined steel Glass or St. S.
F. J. Stokes Mach. Co. Tabor Rd. Philadelphia 20, Penna.	15		5″	Simple batch distillation, batch and continuous fractionation unit Vacuum stills	Copper
Struthers-Wells Corp. Warren, Penna.	16	25′	14″	Simple batch distillation, batch and continuous fractionation unit 20 gal. reaction still	St. S. St. S.
Vulcan Copper & Supply Co. Cincinnati, Ohio	24	28′	8″	Simple batch and azeotropic distillation batch Continuous fractionation units	Copper

tor costs about $4470 when of mild steel construction and has a total evaporation capacity of 350–400 lbs. of water per hour.

Evaporation in these units may be carried out as pressures slightly above atmospheric down to a comparatively high vacuum. The types of evaporators, varying in number of effects, included in this listing are: standard, vertical, long tube vertical, forced and natural circulation, vapor recompression, heat pump type, direct fired, and submerged combustion type. A photo of the last type is shown in Fig. 2. Most of these units are produced in steel, stainless steel or copper construction. Still other materials of construction may be provided. Supporting members are usually of structural steel and generally a considerable amount of instrumentation is provided. With little additional instrumentation, many of these units can be made to serve satisfactorily for evaporation studies. Manufacturers of these "packaged" evaporators are listed in Table II.

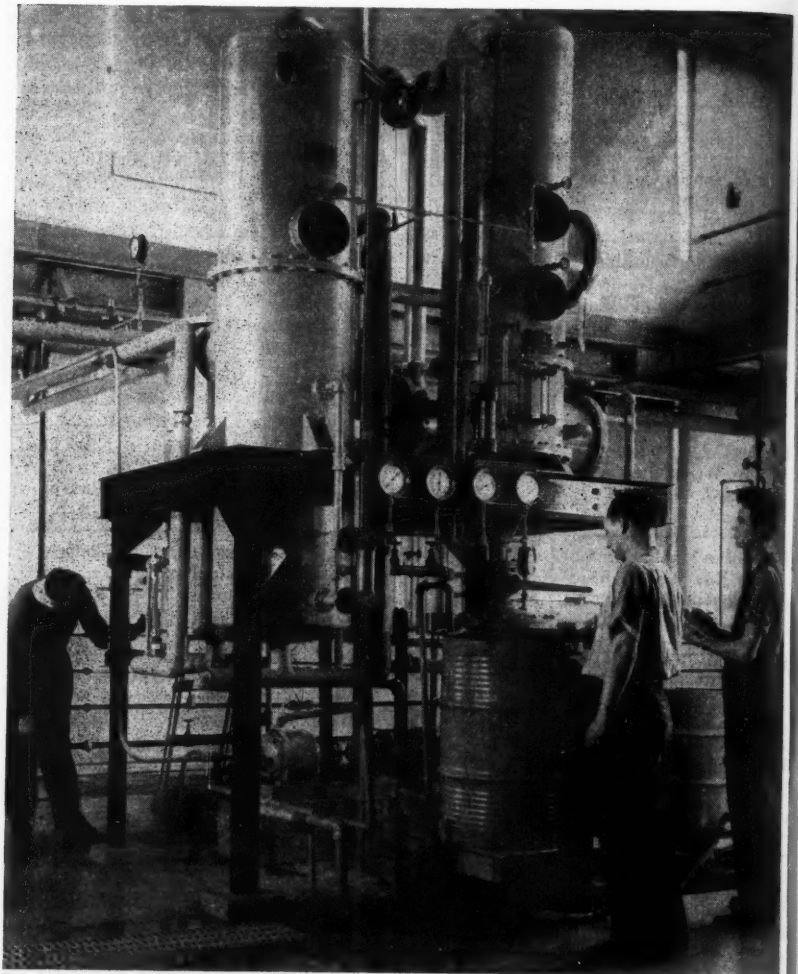

FIG. 1. Double-effect evaporator. (Courtesy: Buflovak Midwest Co.)

Crushing and Grinding: Most educational institutions give instruction in crushing and grinding A sufficiently wide variety of small crushing and grinding units are available to provide any laboratory with considerable versatility in this line. Included in this list are the following: jar crushers, crushing rolls, gyratory crushers, wet and dry grinding units, ball, rod, tube and compartment mills, swing sledge mills, drum rollers and tumblers, hammer mills and conical mills. A typical "packaged" unit is the dry grinding unit pictured on Fig. 3. In

addition to making the crushing and grinding units, most of these companies also manufacture classifying and separating equipment. The manufacturers' data are summarized in Table III below.

Filtration: Equipment for filtration studies has more often been designed by the institution staff. However, quite a few "packaged" type filtration units now are available, employing various methods of filtration. It is difficult to evaluate their adaptability to specific laboratory experiments. Usually filter presses have served for filtration experiments in most laboratories, and the possibilities of using rotary, vacuum, pressure leaf filters, etc., would have to be investigated for the individual application. The price range for these units varies from $400 for a small filter press to $5000 for a stainless steel rotary vacuum filter. The manufacturers of filtering equipment are listed in Table IV.

Extraction: The ever-increasing importance of liquid-liquid extraction as a unit operation is reflected by the number of small units now available for use in experimental work. Probably of most in-

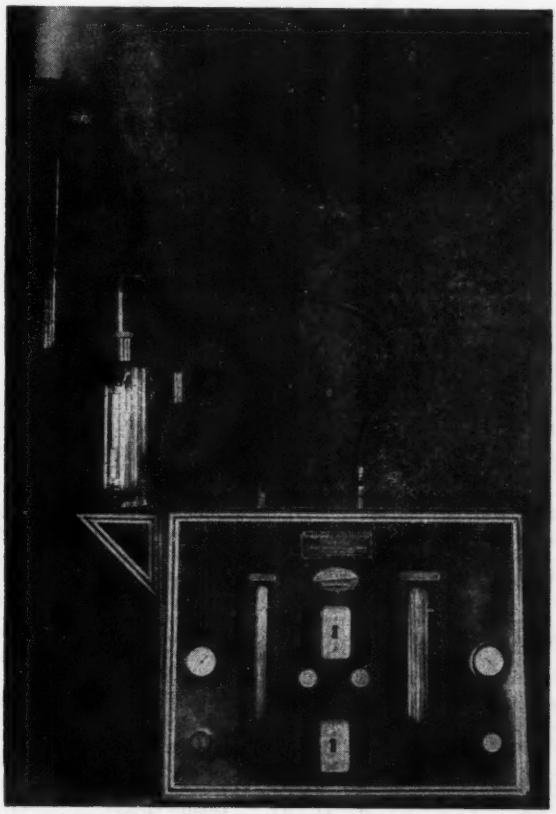

FIG. 2. Submerged combustion evaporator. (Courtesy: Ozark-Mahoning Company.)

TABLE II

Manufacturers of Evaporators

Manufacturer and Address	Approx. Overall Dimens. W × L × H	Type	Materials of Construction
Ansonia Copper & Iron Wks. Cincinnati 4, Ohio	4′ 7′ 9′	Single effect	Copper
Artisan Metal Products Boston 54, Mass.	5′ 12′ 26′	Double effect	St. Steel
Blaw-Knox Co. Pittsburgh, Penna.	4′ 10′ 21′	Single effect	Steel
Buflovak Equip. Co. Buffalo 11, N. Y.	8′ 8′ 12′ 4′ 8′ 12′	Heat pump type and double effect Double effect	Steel and St. S. Steel and St. S.
Goslin-Birmingham Mfg. Co. Birmingham 1, Ala.		Double effect	Steel
Industrial Process Engrs. 8 Lister Ave. Newark, N. J.	4′ 7′ 8′	Single effect Single effect	St. S. St. S.
Arthur D. Little, Inc. Cambridge, Mass.		Vapor recompression	
Mojonnier Bros. Co. 4601 West Ohio St. Chicago 44, Ill.		Standard single and multiple effect and heat pump type	St. S.
Ozark Mahoning Company Tulsa, Oklahoma	25″ 42″ 56″	Submerged combustion	St. S.
The Pfaudler Co. 11 W. Washington Ave. Chicago 2, Ill.	28″ I.D. 10″ depth	Single effect Evaporating pans	St. S. Glass lined steel
F. J. Stokes Mach. Co. Philadelphia 20, Pa.		Double effect	Cast iron, Copper
Struthers-Wells Corp. Warren, Penna.	8′ 15′ 11′ 1′ 3′ 4′	Triple effect Single effect	Steel Pyrex glass
Swenson Evaporator Co. Harvey, Ill.	6′ 14′ 21′	Double effect	
Vulcan Copper & Supply Co. 120 Sycamore St. Cincinnati 2, Ohio	2 single effect evaporator units are available		
Struthers Wells Corp. Warren, Penna.	7′ 8′ 11′ 8′ 11′ 11′	Single effect Double effect	Steel Steel

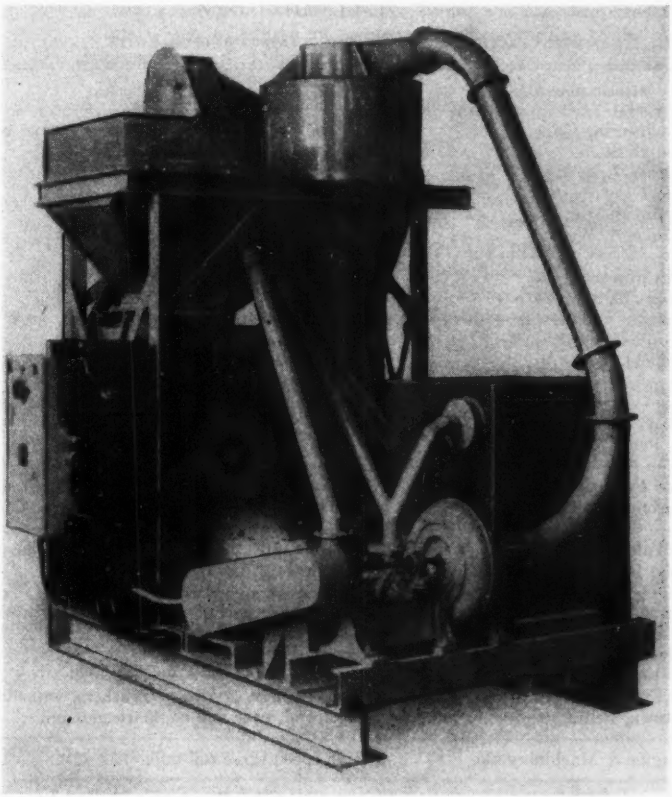

FIG. 3. Dry grinding Unit. (Courtesy: Hardinge Company.)

terest are the counter-current extraction columns of which several types are offered. These are, as a rule, constructed of Pyrex glass or stainless steel. Extraction columns, complete with accessories, range in price from $700 to about $3000. Manufacturers of these "packaged" type liquid-liquid extraction units are listed in Table V below.

Drying: Normally some sort of drying equipment is required for institutional laboratories for unit operations or for other uses. Included in this group of equipment are spray, drum, adsorption and absorption, tray and vacuum dryers, their use dictated by the type of laboratory experiment desired. The price of these units varies from $150 for the small adsorption type of air drier, to $4500 for a larger tray type drier. Table VI is a collection of information for "packaged" type driers.

Heat Transfer: Generally, equipment designed to illustrate heat transfer in the unit operations laboratory is a special problem that must be handled by the individual staff. However, there are a number of firms who manufacture heat exchangers and who are in a position to fabricate such equipment on the basis

TABLE III

MANUFACTURERS OF CRUSHING AND GRINDING UNITS

Manufacturer & Address	Type of Equipment
Abbe Engineering Co. 50 Church St. New York 7, N. Y.	Jar mills, jar rolling machines, pebble and ball mills
Allis-Chalmers Mfg. Co. Milwaukee 1, Wis.	Crushing rolls, jaw crushers
American Pulverizer Co. St. Louis 10, Mo.	Hammermills, crushers, shredders
Bauer Bros. Co. Springfield, Ohio	Grinding mills
Hardinge Co., Inc. 240 Arch St. York, Penna.	Wet grinding mills, conical dry grinding mills
Patterson Foundry & Mach. Co. East Liverpool, Ohio	Wet and dry grinding equipment, ball mills, jar mills, crushers
Sprout-Waldron & Co., Inc. Muncy, Penna.	Attrition mills, hammer mills, roller mills, crushers, grinders
Sturtevant Mill Co. Park & Clayton St. Dorchester, Boston 22, Mass.	Rolls, jaw crusher, crushing rolls, grinder, swing sledge mill, coal crusher
Traylor Engr. & Mfg. Co. Allentown, Penna.	Jaw crushers, gyratory crushers, crushing rolls, ball, rod, tube and compartment mills.
Troy Engine & Machinery Co.	High speed three roll mills
U. S. Stoneware Akron 9, Ohio	Jar mills, ball mills, drum rollers and tumblers

of the customer's specifications. These are listed below in Table VII.

Other Unit Operations: Not all of the unit operations are illustrated in experiments in every laboratory. Gas absorption, crystallization and leaching are those which may not be illustrated. "Packaged" units are available for these as well. The Struthers-Wells Corporation, Warren, Pennsylvania, manufactures an absorption column having an outside diameter of 14 inches containing 12 bubble-cap trays. The overall dimensions of this unit are 2 feet by 2 feet by 22 feet. Another unit is made by Carter & Nansen Company, Inc., 415 Lexington Ave., New York 17, New York, but the authors do not have the specifications for their equipment.

For crystallization studies an evaporative type unit is available from the Swenson Evaporator Company, Harvey, Illinois. This unit is constructed from stainless steel and the overall dimensions are 3 feet by 8 feet by 10 feet. In addition, a Swenson-Walker type continuous crystallizer can be obtained from the above manufacturers.

The Dorr Company, 221 North LaSalle St., Chicago, Illinois, manufactures a bench model countercurrent decantation unit which can serve for an experiment in leaching. A photo of this unit is shown in Fig. 4.

Special Unit Operations Equipment: Often special characteristics are required in unit operations equipment, and it may not be possible to incorporate them in any of the standard "packaged" units already available. Manufacturers of industrial equipment who ordinarily do not construct small units, are willing to construct such units from a design drawing and/or sketches submitted by the customer. These companies are listed below in Table VIII and are in addition to those listed in previous tables. In general, manufacturers of standard "packaged" unit type of equipment mentioned in previous Tables are also prepared to fabricate such units according to the customer's specifications.

Other Sources of Unit Operations Equipment

Sometimes a limited budget may call for the purchase of used but serviceable equipment. Often new equipment is not essential. The present survey indicates that R. Gelb & Sons, Inc., State Highway No. 29, Union, New Jersey and First Machinery Corporation, 157 Hudson St., New York 13, New York, can provide such serviceable equipment. However, care must be taken in the selection of units having sufficiently small capacity. The authors are aware that the survey of used equipment suppliers is by no means complete.

TABLE IV

MANUFACTURERS OF FILTRATION UNITS

Manufacturer and Address	Filtering Area	Materials of Constr.	Overall Dimens.	Type of Unit
Alsop Engrg. Corp. Milldale, Conn.				Disc pak filters
Eimco Corp. Salt Lake City, Utah	4 ft.^{2}	St. S.	3′ × 5′ × 5′	Vacuum filter
Filtration Engrs., Inc. 155 Oraton St. Newark 4, N. J.	3 ft.^{2}	St. S.		Rotary vacuum filter
Hercules Filter Corp. 204–208 21st Ave. Paterson 3, N. J.	½ ft.^{2}	Bronze nickel or St. S.		Pressure leaf filter Sheet filters
J. Shriver & Co., Inc. 808–864 Hamilton St. Harrison, N. J.	5.7 ft.^{2} 5.0 ft.^{2}	Monel metal Monel metal		Filter press Filter press
Tite Flex Inc. 500 Trelmghuysen Ave. Newark 5, N. J.	½ ft.^{2}	St. S.	7″ × 11″ × 21″	
First Machinery Corp. 157 Hudson St. N. Y. 13, N. Y.				Many types available

TABLE V

MANUFACTURERS OF EXTRACTION UNITS

Manufacturer and Address	Capacity	Overall Dimens. W × L × H	Matr. of Constr.	Type
Artisan Metal Products, Inc. 73 Pond St. Waltham 54, Mass.		2′ 3′ 7′ 2′ 3′ 7′	 St. S.	Soxhlet extractor Extraction tower
Brighton Copper Wks. Cincinnati, Ohio			Copper	
The Pfaudler Co. 111 W. Wash. Ave. Chicago 2, Ill.	10 gal.		St. S.	Soxhlet extraction
Podbielniak, Inc. 341 E. Ohio St. Chicago, Ill.	500 cc./min.	22″ 19″ 21″	St. S.	Centrifugal solvent extractor
F. J. Stokes Mach. Co. Tabor Rd. Philadelphia 20, Pa.				Vacuum extractor
Vulcan Copper & Supply Co. 120 Sycamore St. Cincinnati 2, Ohio				Liq.-liq. and liq-solid extraction units
Otto H. York Co., Inc. 364 Glenwood Ave. E. Orange, N. J.	10 gal. 7 gal.	1′ 2′ 9′ 2′ 3′ 9′	Pyrex glass Pyrex, St. S.	Liq-liq. column Scheibel tower

Conclusions

The authors have consulted the Chemical Engineering catalog as a primary source of "packaged" type equipment for use in Unit Operations laboratories, especially in educational institutions. These units are just as useful for small scale industrial operation. Manufacturers have been listed according to the particular unit operation and pertinent data, in so far as was available was also listed.

If the specifications for a preferred unit were greatly different from those of the standard "packaged" unit, the authors found that the cost was nearly double that of the standard unit. It is suggested that "packaged" units be purchased and later modified into the preferred units by the addition of such standard items as are necessary. In this way both staff effort and cost can be reduced.

The suppliers listed in the charts will fabricate to specifications or drawings and/or sketches supplied by the customer. Needless to say, the cost is lower when detailed specifications and drawings are supplied.

Acknowledgment

The authors wish to acknowledge the assistance of Mr. Wallis Lloyd in the preparation of the tables and manuscript. They are indebted to the respective companies for the information and photographs of the "packaged" units, to the Information Services of the American

TABLE VI

MANUFACTURERS OF DRYERS

Manufacturer and Address	Type	Materials
Artisan Metal Products, Inc. 73 Pound St. Waltham 54, Mass.	Work done to specifications	Stainless steel
Bowen Engrg., Inc. North Branch, N. J.	Spray dryer (50–500 cc./min.)	Stainless steel
Blaw-Knox Co. Pittsburgh, Penna.	Rotary vacuum dryer	
Buflovak Equip. Co. Buffalo 11, N. Y.	Double drum dryer	Cast iron, sheet steel
Davison Chem. Corp. Baltimore 3, Md.	(50–150 c.f.m.) Silica gel air dryer	Aluminum
Despatch Oven Co. Minneapolis 14, Minn. (619 S. E. 8th St.)	Tray dryers	Any material
R. Gelb & Sons, Inc. State Highway No. 29, Union, N. J.	Vacuum drum dryers	
C. M. Kemp Mfg. Co., Inc. 405–15 E. Oliver St. Baltimore 2, Md.	Air, gases, liquids	
National Drying Machinery Co. 2709 N. Hancock St. Philadelphia, Penna.		
Niro Corporation 98 Franklin St. Bloomfield, N. J.	Spray dryer	Stainless steel
Pittsburgh Lectrodryer Corp. P.O. Box 1766 Pittsburgh 30, Penna.	Air dryers (100 ft.^{3}/hr.)	Stainless steel
Proctor & Schwartz, Inc. 7th St. & Tabor Rd. Philadelphia 20, Penna.	Tray dryers	Iron and steel
Selas Corp. of American Erie Ave. & D. St. Philadelphia, Penna.	(50–150 c.f.m.) Silica gel dehydrators	Stainless steel
F. J. Stokes Mach. Co. Tabor Rd., Phila. 20, Pa.	Sublimation dryer	
Swenson Evaporator Co. Harvey, Ill.	5–25 lb./hr. Spray dryer ,	Stainless steel

TABLE VII

MANUFACTURERS OF HEAT EXCHANGERS

Andale Co.
Philadelphia, Penna.

Artisan Metal Products, Inc.
73 Pond Street
Waltham 54, Mass.

Brighton Copper Works, Inc.
2144–2160 Colrain Ave.
Cincinnati 14, Ohio

Doyle Roth Co.
Newark 5, N. J.

Graham Mfg. Co., Inc.
415 Lexington Ave.
New York 17, N. Y.

The National Radiator Co.
221 Central Avenue
Johnstown, Penna.

Patterson-Kelley Co., Inc.
East Stroudsburg, Penna.

The Pfaudler Co.
111 W. Washington Street
Chicago 2, Ill.

Struthers-Wells Corp.
Warren, Penna.

Zaremba Co.
Buffalo 2, N. Y.

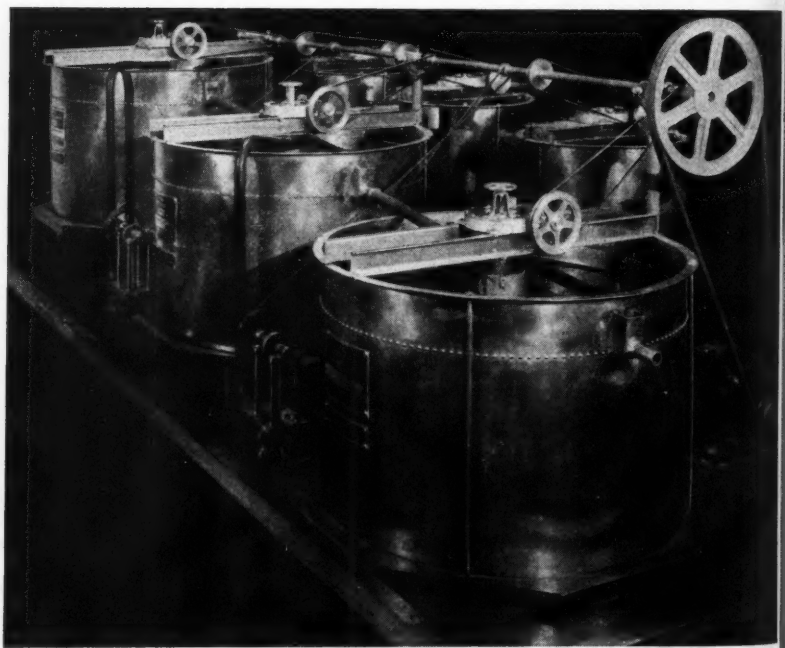

FIG. 4. Counter-current decantation unit. (Courtesy: Dorr Company.)

TABLE VIII

MANUFACTURERS OF SPECIAL UNIT OPERATIONS EQUIPMENT

Acme Coppersmithing & Mach. Co.
Oreland, Penna.

Alloy Fabricators, Inc.
Perth Amboy, N. J.

S. Blickman, Inc.
702 Gregory Ave.
Weehawken, N. J.

Emerson-Scheuring Co.
Martindale Ave., at 21st
Indianapolis 7, Indiana

Farwell, Ozmun & Kirk Co.
Kellogg Blvd. & Jackson
St. Paul, Minn.

Stainless Steel Products
1000 Berry Ave.
St. Paul, Minn.

L. O. Koven & Brother, Inc.
154 Ogden Ave.
Jersey City 7, N. J.

Patterson-Kelley Co., Inc.
East Stroudsburg, Penna.

John Van Range Co.
422 Eggleston Ave.
Cincinnati, Ohio

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General Objectives of the Engineering Program from the Standpoint of the Evening Graduate Program

By ROBERT W. VAN HOUTEN

President of Newark College of Engineering

In discussing this topic it should be kept in mind that some subjects are primarily of direct benefit to the individual student—who is very probably an employee of industry and through whom industry may indirectly benefit—and others are of primary and direct benefit to industry. In order to serve industry, indirectly and directly on the graduate level, some courses may lead through a formal program to the Master's or Doctor's degree, while others may be part of a non-credit program on the graduate level.

Background of Students

The first topic of importance which should be examined briefly is the composition of the group for whom these evening engineering graduate programs are offered and which can roughly be considered to consist of three general student categories. First of all, not necessarily in order of importance but undoubtedly first quantitatively, are those young graduates who completed their undergraduate studies during the day and who accepted employment after graduation instead of beginning their graduate work on a full-time basis. Some of these men may have been forced to do so because of economic conditions. Personal or family finances may have been such that they deemed it necessary to obtain employment after completing their baccalaureate programs. Others may have decided that it was advisable to accept an exceptional employment opportunity at graduation rather than to risk the possibility of locating as attractive a position a year or two later. It is easy to understand how the student graduating in 1948 or 1949 might have viewed this situation in the light of what he may have heard would probably be the employment situation in, for example, 1950, and possibly 1951.

Among former day students are some who, after four years of formal instruction, welcomed freedom from academic studies but who after two or three years in industry realize the importance of further study on the graduate level. These men are, in general, not in a position to forfeit their positions in industry. They have a certain amount of seniority, their salaries have begun to reflect three or more years of employment, and many of them have undoubtedly assumed family responsibilities. The only course open to them is graduate study in the evening.

A second general group is, of course, composed of those men who earned their undergraduate degrees through evening study. Their situation is parallel to that of the group just discussed but is, of course, even more seriously affected by such factors as seniority, company advancement, financial obligations, and family responsibilities. These men, with rare exceptions, must, if they wish to continue their education, do so during the evening hours.

Finally, there is a third group—possibly the smallest of the three but, nevertheless, important—composed of those employees who lack a formal undergraduate education but who, through

personal study and industrial experience in a specific field, need further training on the graduate level. They are not candidates for advanced degrees but do compose a group for whom the evening engineering college should render service, either by admitting them as auditors to selected courses for which they have adequate prerequisite knowledge, or to non-credit courses on the graduate level. For example, an individual could lack an undergraduate degree in engineering but could have sufficient knowledge and experience in, let us say, the field of metallurgy to profit from advanced instruction in this field.

Academic Standards of Evening Courses

Next, what of this group of young people as a whole for whom evening graduate instruction is offered?

There are those who have had little or no experience with evening programs who contend that evening students cannot maintain the same standards of performance as day students, or they argue that, if the evening student attempts to maintain high standards, his day work suffers.

Those of us who have had considerable experience with evening programs know this not to be the case. Evening courses attract ambitious employees who want to advance themselves, and on the graduate level you find, in general, students of superior ability who are intensely interested in furthering their education in their specific field of interest and/or employment. The contention that the day work of the evening student suffers is also fallacious, as it assumes that the worker who is not studying evenings reports to work fresher than his studious counterpart. As a matter of fact, the student who is devoting some of his evenings to graduate study may be a much better employee and in better physical condition when he reports to work. Moreover, the evening graduate student brings to his courses an educational background and industrial experience which results in a greater appreciation on his part of the subject matter presented, and which permits a sharing of experiences with other members of his class to the mutual benefit of all. Furthermore, because employees in the industrial areas, in which most colleges offering evening work are located, are recruited from many colleges, you find in evening graduate programs students with a wider variety of educational experiences than is found in the average day program. In our evening graduate division, which is comparatively new and which this year has about 400 students, we have, in addition to our own graduates, 68 colleges represented, including McGill University and the Ecole Polytechnique of Montreal. This diversity of collegiate background makes for a much broader viewpoint and more comprehensive discussion in the classroom.

Finally, the evening graduate program can present, as lecturers, specialists, practicing engineers, research experts, operating executives, etc., who are not, in general, available for daytime courses. So much for those who are to be served by the evening graduate program and what this program can offer them.

What Industry Expects

Next, what, in general, is industry expecting of the young engineering graduate, both with respect to his undergraduate education, and his further training? Industry is, in general, asking that graduates be grounded in the fundamentals, with the very specialized training being left in the hands of industry. This is, I believe, as it should be, though we always seem to be faced with a constant struggle to obtain an appreciation on the part of some individuals that a thorough grounding in fundamentals is far more important than an attempt to cover less thoroughly a wide range of subject matter. Industry, by and large, unquestionably prefers the student well versed in fundamentals to one who has covered many subjects somewhat less rigorously.

In addition to such specialized training as industry may give the young graduate in its own programs, it would also appear desirable that the student taking graduate work possess the following:

1. A more comprehensive background of knowledge than is generally expected of the undergraduate student.
2. Familiarity with problems involving more advanced techniques than are taught the undergraduate student.
3 Versatility in knowledge techniques permitting a flexibility on the part of the employer and student which will be of benefit to both.
4. Acquisition of a deeper insight into technical problems from the point of view of the industry and its relation to pure science on the one hand, and the consumer on the other.

In a limited number of cases there is a demand on the part of the student and industry for study on the pure research level.

In discussing graduate training, let me inject one word of caution to the effect that, with all that has been said about graduate education, it cannot of itself counteract personality and character weaknesses. It can render service in the areas indicated but it cannot change the character of the individual who may be technically proficient, but, from the standpoint of personality, a total loss to industry. Great teachers may have a profound effect on an individual of that type, but additional formal education per se will very likely effect no change.

Objectives of an Evening Graduate Program

Now having considered briefly the individuals to be served and what industry expects of the young engineer, we next come logically to the question of what should be the objectives and philosophy of the evening graduate program. Fundamentally they should be the same as that of a sound day graduate program namely, the education of the whole man, good general technical education, and flexibility regarding specialization. I a a firm believer in the necessity for broad an education as we can possibl offer in the field of engineering. Tha has long been the fundamental philosoph of our undergraduate program. It w developed under the leadership of D Cullimore, who came to Newark Colleg of Engineering in 1920, and that sam philosophy has been carried over int our graduate program.

The principle of a good general tech nical education beyond the undergraduat level is undoubtedly accepted witho question. Very specialized training shoul be delegated to industry, and, to som extent, to work on the doctoral level The third factor, flexibility, is importan for at least two reasons. First, it per mits a broader education and, secondly it gives the student an opportunity t study in some field other than that i which he did his undergraduate work For example, a student who received hi Bachelor of Science degree in Mechanica Engineering may, because of his presen employment, or interest, wish to do hi graduate work in Management Engineer ing. This opportunity should be avail able to him in the graduate program Maintaining flexibility is, I believe, e tremely important. You will probably recall that, at the Troy meeting las June, the statement was made that "o the average more than 20 per cent of th men graduating in one branch of engi neering find employment in another." This statement serves to strengthen fur ther my conviction that undergraduat education should stress fundamentals and the graduate study should continu to develop the whole man, advance hi general technical education and, at th same time, provide a program which i flexible.

Finally, with respect to curricula, le me emphasize the importance of con tinuous attention to a study of the cur

ricula so that they may meet current and future needs of the student and industry. They should never be static, but, when I say that, I do not mean to imply that they should be subject to the whims of individuals who may be intensely interested in specialities which serve no general or useful purpose and do not fall within the scope of graduate education. Neither should the curricula be subject to pressure groups who may promise financial support, gifts of equipment, etc., as inducements to introduce into graduate curricula subjects of restricted value which have no place within the broad philosophy of the graduate program.

Having said that, however, let me add that specific courses of the type to which I have just referred may justly be given within the scope of a non-credit program and, as a matter of fact, could, and probably should be, coordinated with the specific training programs of industry.

Problems of Financing Programs

Before concluding this talk I do want to comment on the matter of financing the several types of graduate subjects offered. First, at one extreme, is the type of subject which is of primary value to the student and which should be paid for by the student.

At the other extreme are other subjects, probably non-credit, which are basically of value to a specific group of industries rather than to the individual student. These, it seems to me, should be financed by industry rather than the student. As a matter of fact, during the war we had an example of this type of financial support through the medium of the ESMWT programs. While the government, rather than industry, was subsidizing the program, it was doing so in order to make it attractive for individuals to upgrade themselves and thus increase their value to their country through greater service to industry.

Between these two extremes there are also other subjects which are of benefit to the student and industry both and which should receive mutual support from both the student and industry.

There is another factor in the problem of financing graduate programs on which I have not commented and that is with respect to the extent to which public and private colleges should subsidize graduate work from public appropriations or private endowments. This is, of course, of considerable importance and the determination of the extent of any subsidy is a matter for each individual institution to decide, within the scope of the philosophy of its governing body.

There is one point concerning tuition charges on which I should like to comment, and that is with respect to the practice of charging for subjects by the credit-hour rather than by the contact-hour. We do it ourselves, but it does not make sense to me. For example, assuming a tuition charge of $15 per credit-hour, we find that a three credit course, such as Mathematical Statistics (3 class hours per week), carries a total tuition charge of $45, while a six credit course, for example, Advanced Unit Operations (3 hours of lecture and 6 hours of laboratory period), would rate a tuition charge of only $90. In the second case we are giving three times as much instruction for only twice the tuition. In addition, it probably costs as much or more for the laboratory subject if instruction is going to be of the same caliber as the lectures and if the cost of special materials is included. I realize that the rates can be averaged so that theoretically the college does not lose, but, in so doing, it seems to me that the student taking a lecture course is carrying some of the financial burden of the student taking laboratory work. It would appear to me that the only fair basis for tuition charges is the contact-hour rather than the credit-hour. We do this in our undergraduate program, and I hope that we can make the change in our graduate division before too long.

Perhaps I should touch upon the sub-

ject of research, but, because of time limitations and because of the broader aspects of the graduate program, which are probably of more general concern and interest, I am going to say only a word or two. I do want to inject a word of caution to the effect that the colleges carefully consider the type of research projects undertaken. They should certainly be of general interest and should not involve research solely of value to a specific industry or company at public expense. A public institution must be particularly careful not to compete with private research laboratories which are contributing to the support of the public institution through the payment of taxes.

I am convinced that there will be an increasing demand for graduate courses and that the colleges offering evening graduate programs are in a particularly fortunate position in that they have not only a responsibility, but also an exceptional opportunity to serve students and industry by offering evening programs which will meet the needs of both.

Objectives of a Program of Engineering Education in Evening Classes*

(From the Undergraduate and Non-Credit Standpoint)

By HAROLD TORGERSEN

Assistant Dean In Charge of Evening Division, College of Engineering, New York University

A program of evening classes in engineering should be considered in two parts. There seems to be a need for a regular undergraduate program leading to a degree and for a program of non-credit courses. In this presentation the regular undergraduate program will be considered first and the non-credit program second.

The general objectives of the regular undergraduate program offered in the evening should not be different from the objectives of any regular undergraduate program. These objectives, it seems to me, are two-fold. Primarily, the purpose of our undergraduate program in engineering, or in any other field, should be the general education of a student. The program should be organized to develop the intelligence of the individual student. This development should include a rigorous discipline in analytical thinking as well as a development of the social consciousness (and if possible the social conscience) of the individual student.

The second objective of a program of engineering studies should be to provide some measure of vocational training for the student. The details of the portion of the curriculum to be devoted to vocational training of necessity will differ in different institutions. Whatever the details of the curriculum, certain special problems and opportunities arise when the students are employed full-time in business or in industry, as they are when enrolled in an evening program. I do not believe, however, that these problems and opportunities should be permitted to cause any basic modification of the cur-

* Presented before the Evening Engineering Division at the Annual Meeting of the ASEE, Seattle, Washington, June 21, 1950.

riculum which would make it fundamentally different from a regular four-year day program.

While maintaining in the evening program the same basic curriculum which seems proper for a full-time day course, it is desirable to recognize that students who are employed in industry often have a background of experience which can be utilized to advantage by their teachers, particularly in advanced courses. This necessitates a modification of the presentation in some courses if the students are to make the best use of the time they devote to such courses. It is possible to cite from our experience at New York University numerous examples of this.

In our courses in Time and Motion Study we have found it possible to have students in the evening division bring in problems or projects from their places of employment and to use these effectively for class analysis and study. In our courses in Technical Writing we have found that many of the students in the evening division can work on topics directly related to their jobs in industry.

While in general the student who is employed in industry while he is attending college finds his industrial experience helpful in his college work, occasionally difficulties arise because of such experience. Some students become overanxious to complete the specialized courses directly related to their jobs and try to avoid taking a well balanced program. This tendency must be resisted firmly by those responsible for the administration of the college program.

Turning now to the field of non-credit courses, we are confronted with a program whose basic philosophy is quite different from that of the regular courses leading to a degree. Such courses are found to be of a rather narrowly specialized nature. Their primary purpose is to supply information and their value in raising the intellectual abilities of the students who take them is, in my opinion, very dubious. In my opinion, any program of non-credit courses should be segregated carefully from the program of courses leading to a degree.

The need for non-credit courses arises from the desire of local industries for men with specialized training, generally of a sub-professional level. Before undertaking to offer such courses a college or university should make a careful study of the matter in collaboration with the industries concerned. Often it will be found that as a result of such a study a well coordinated group of courses can be developed. For some of the students preparatory courses will be found desirable. These generally can be worked out to serve several groups of students.

Our experience in this field has led to the development of a two-year program in Mechanical Equipment of Buildings, including courses in Heating, Ventilating and Air Conditioning and to a program in Building Construction and Estimating. These courses are administered by the Division of General Education of the University and carry no college credit. Some members of the faculty of engineering serve in an advisory capacity in planning these programs. In general, however, the instructors are drawn from industry.

To sum up, then, the objectives of a program of engineering education in the evening should be to meet the needs of the area served by an engineering college. For some students a regular degree program will be found desirable. For others, an array of specialized non-credit courses will better meet the need.

What Program for the Young Instructor?*

By FRANK KEREKES

Assistant Dean and Professor of Civil Engineering, Iowa State College

The young instructor should be prepared to assume increased responsibilities as the opportunities arise. In anticipation of reasonable and steady advancement, he needs, first to think through and to determine the objectives he wishes to achieve during his career as an engineering educator. Then, he should plan a program that will systematically lead toward the goals he has set for himself. The formulation of these objectives and the achievement of the program are dependent upon controllable personal factors and upon imposed external factors. The controllable personal factors depend primarily upon the ability, energy and determination of the young instructor; the imposed external factors are established by the precedents and policies of the institution where he teaches. In any case the young engineering educator who wants to be successful in his work has to pursue and to assume a threefold objective and responsibility: he must become a good engineer; he must become an effective teacher; and, he must become an inspiring leader of students and men. Each young instructor will need to develop objectives and program in terms of his own interests and abilities. The following discussion should serve primarily as source material from which each person may select those suggestions which apply to his case and desire.

Becoming a Good Engineer

The young teacher brings to his classes a certain amount of technical skill gained from his engineering studies, his part time summer work, and his practical experience for one or more years with an industry, the government, a contractor, or an engineering firm. In general, many engineering educators have had only a few consecutive years of practical experience. Most of these occurred in the few years immediately following graduation from an engineering school. Occasionally, however, one will find eminent teachers who have become associated with engineering education after a reasonably long and successful career in engineering practice. In a number of instances teachers have taken a year's sabbatical leave; in some others, a few have actually discontinued their teaching connections to enter engineering practice for about two or three years and, then, to return to the teaching field, usually at some other institution.

In reasonably normal times teachers may take advantage of their nine- or ten-month academic year to find engineering employment during the summer months. Thus, a teacher can accumulate one year of profitable, diversified and practical experience during intervals of four to five years of teaching. Diversification can be obtained either by changing employers every second or third summer or by getting opportunity to do more responsible work each summer, at the same place of employment. During the early years of teaching these summer jobs offer welcome changes from class room responsibilities and excellent opportunities for extending one's engineering skill and professional acquaintances. These experiences and friendships become very helpful

* Presented before the Civil Engineering Division, at the Annual Meeting, Seattle, Washington, June 20, 1950.

in the later years of one's teaching, not only as a means of keeping in touch with engineering developments but also in making contacts for the employment of graduates. These associations are of mutual advantage to the employer who needs new recruits from recent engineering graduates. He gains first hand knowledge of the teacher's technical ability and professional attitudes and, therefore, he has more confidence in the students trained by teachers who have worked for him.

The records of many eminent teachers of engineering selected at random from among recipients of the Lamme and Westinghouse awards illustrate the large variation in the time devoted to gaining practical experience. The young teacher of engineering needs to apply foresight, initiative, courage and determination to make the effort and investment required to gain indispensable and essential practical experience that will enable him to become a good engineer.

"Becoming a good engineer" is an important phase of the young instructor's program throughout his teaching career. If, at any time, he stops the processes of becoming a good engineer he also stops being a good teacher of engineering. Memberships in professional engineering societies offer the medium in which the teacher may continue to grow as an engineer, both technically and professionally. The young instructor should make it a MUST, an important part of his program, to join at least three societies: the statewide engineering society whose membership is available to engineers in all branches of practice; one major national technical society which represents his broad engineering interest such as civil, chemical, electrical, or mechanical engineering, or other similar groups; and the American Society for Engineering Education which provides opportunities for development as a teacher through published articles in the Journal of Engineering Education, through committee work in one of the Divisions and through the presentation of papers at Sectional and National meetings. Later as the teacher's interest narrows down to a preferred specialty he will apply for membership in additional technical societies which devote their entire attention to specialized fields such as the American Concrete Institute, the American Water Works Association, The American Society of Heating and Ventilating Engineers, The Institute of Radio Engineers, The American Management Associations and others too numerous to mention. Nevertheless, the engineering teacher should consciously maintain a broad as well as specialized attitude toward engineering practice and education.

Memberships in these societies imply energy and time-consuming responsibilities if they are to play an important role in the development of the young instructor into a good engineer, a good teacher and a good citizen. In the early years the most he can do will be to study those articles which have an immediate and direct bearing upon the courses he is teaching and the courses he would like to teach in the future. He should scan each issue of the regular publications in order to be aware of the problems of his professional group and their relations with the public. The contacts with his statewide society will keep him informed about the local professional, social, economic and legislative problems of his engineering associates. The regular issues of the Journal of Engineering Education will provide him with many ideas for self-improvement in teaching methods and educational practice and policies. Above all he will begin to build up an acquaintance and an appraisal of the men who are actively contributing to engineering technique and education. Then when he goes to the annual meetings of the societies with which he has previously established a paper acquaintance he will speak on more intimate terms with the men whose names he found in the regular publications. He will be able to discuss with them briefly but effectively some portion of their published paper or article. He will make acquaint-

ances that will grow into lifelong friendships.

As the young instructor grows in professional stature he will submit written discussions to major papers in his special field. The stimulation he has received from his society membership will encourage him to attempt an original paper on a subject to which he has given considerable thought and time. Or, he may impress his associates with his judicial attitudes and administrative aptitudes. Then he will find that he is appointed to a committee dealing either with technical problems or society affairs. His associates will recognize his qualities of leadership and elect him at first, to minor offices, and gradually, on his ability to get results he will find himself holding offices of major responsibility. Yes, by getting an early start, by working continuously and effectively, he will find that after ten or twenty years he has become one of those good engineers who used to inspire him when he was a young instructor. The achievement of an objective to become a good engineer has been consummated by steady, intelligent and sincere adherence to a well planned program.

Becoming an Effective Teacher

Experience in engineering practice enhances the potential effectiveness of the teacher and the spontaneous respect of his associates as well as his students. Having successfully coped with the challenge of practical engineering problems, processes and situations, the teacher is in an authoritative position to select practical applications wisely, to employ engineering knowledge and approach naturally, to evaluate the engineering judgment of students accurately, to introduce practical experiences vividly, and to create professional attitudes realistically. These qualifications of the good engineer supply the essential professional ingredients of good teaching.

Evidence points to the conclusion that in the future, as in the past, the engineering teacher will have to acquire teaching techniques, the art and science of teaching, and operational teaching functions after his employment on the staff of an engineering school. This places a responsibility on the teacher to plan for his self-improvement. Furthermore, the head of the department should counsel the young instructor in the planning of a program for professional progress and educational effectiveness. The administrative officers of the college should formulate and support policies whereby the program of the teacher may be achieved.

At first the young instructor will be very busy clarifying in his own mind the fundamental concepts and the essential subject matter of the courses he teaches. He quickly perceives the wide gap between his former student attitude toward learning and the more exacting requirements for teaching. Many young instructors remark that they really didn't begin to master a subject until they had to teach it. At first, in most established departments, the young instructor will need to make very few decisions in regard to course outlines and text books. Above all he will meet his classes with little more knowledge of how to teach than he can remember about the methods employed by some of his former professors. The merit and effectiveness of these vaguely recalled methods are seldom challenged. It is little wonder that the young instructor will devote much of his time and effort to check if the students can remember the text they studied the day preceding. He will spend considerable time in explaining the derivations of formulas which are well presented in the text book but which may have had a few simple algebraic steps omitted. He will also devote some time to the explanation of the next day's assignment. It is no exaggeration and a sad commentary on the teaching methods employed in engineering to state that the methods here attributed to the young

instructor are in too many instances the methods employed by senior professors in senior subjects.

To correct this situation at the earliest possible opportunity the young instructor should obtain some good books on "How to Study." The chances are that no one took the trouble to call to his attention that there are principles and methods on how to study effectively. While he was a student he just trusted to luck that his improvised procedure would yield results. He invested four years of his time and money in a college education without questioning whether he was studying and learning or merely memorizing facts and imitating methods. As a young teacher he will have to know how to study because he will have to study by himself if he is to get anywhere as an engineer and an educator.

As soon as possible after the first year the young instructor should arrange a definite program for studying the art and science of teaching. There are several ways to acquire these skills. Where no formal opportunities exist he should search the library stacks until he finds a few good books on educational psychology and on teaching methods. Perhaps, a planned conference with a member of the Department of Education will enable him to select his books more objectively. Having selected one or two likely texts he should study these as systematically and thoroughly as he studied his engineering texts. As he masters the subject chapter by chapter he should start at once to apply the principles and techniques to the daily teaching of his classes. This formal study of one or two texts should be accompanied by reading the references suggested in the text. Other good supplementary material can be found by regularly referring to the *Journal of Engineering Education*. It is assumed of course as mentioned earlier in this paper that the young instructor joined the American Society for Engineering Education at his earliest opportunity. This affiliation will awaken a genuine interest to use improved teaching methods, it will develop enthusiasm for the teaching profession, and it will provide, in addition, a fine background for a broad understanding of the objectives and philosophy of engineering education.

Another way to improve one's skill in teaching is to organize a small discussion group at the beginning of the academic year. The size of this group should be limited to eight or ten young engineering instructors. Two one-hour meetings a week would provide a 60-hour course before the end of the school year. The selection of the leader should be based on his proven ability to lead his classroom discussions on teaching methods and on his desire to help young engineering instructors establish permanent interest in good teaching.

It was the writer's privilege to organize a group of this kind more than twenty years ago. Twice each week Professor W. H. Lancelot, then Head of the Department of Vocational Education at Iowa State College, held a seminar class between four and five in the afternoon. The topic, Teaching Skills, was thoroughly discussed by the group under his skillful guidance. The subject was tactfully and painstakingly developed by class discussions of the following skills:

1. *"Developing Permanent Interest."* Developing in the students an enduring interest in the subject or course that they are to study.

2. *"Creating a Feeling of Need."* Arousing and sustaining in the class a feeling of need for the knowledge to be learned or for the skill to be acquired, before either teaching it or requiring that it be studied.

3. *"Making Internal Connections"* The interest of the class can be carried from one part of a course or subject to another by relating the new work to that with which the class is already acquainted.

4. *"Making External Connections."* There are many natural and close connections with facts and experiences outside of a topic or course which the alert

teacher can make and in which the students themselves are already interested.

5. *"Involving the Natural Impulses."* A number of natural impulses such as activity, curiosity, creativeness, self-advancement and others should be involved in the planning of a study assignment or class exercise.

6. *"Replace Routine Memorization with Interesting Thinking."* Each essential fact, principle or law can be introduced by a specific problem.

7. *"Creating and Maintaining Suspense."* In every class a state of suspense regarding the outcome will generate spontaneous thinking among the students.

8. *"Developing the Ability to Think Well."* Before the students are willing to substitute good thinking for memorized methods and procedures they must become deeply interested and keenly aware of the need for and value of the ability to think well.

9. *"Finding, Judging and Using Problems."* As a rule problems that represent typical and recognizable life situations are considerably more effective than artificial problems.

10. *"Presenting the Problem."* In general each new problem should be the outgrowth of previous problems which the students have solved by good methods of thinking.

11. *"Planning for the Class Discussion."* Good class discussion is the essence of good teaching. When a teacher can reverse the usual custom of speaking 90 per cent of the hour, he may consider himself to be on the road to success. A good discussion moves along to accepted conclusions.

12. *"Leading the Class Discussion."* The problem should be stated in an interesting and clear manner. A number of viewpoints should be encouraged so that certain members of the class will take sides to support each idea proposed. The teacher can hold the balance of power first throwing his support to one side and then the other. By this procedure the students will be stimulated to think up ideas to prove their points.

13. *"Questioning."* At the beginning of each class call upon those who appear to be keenly interested. Then tactfully bring into the discussion the remaining members of the class.

14. *"Selecting the Fact Materials to be Taught."* To select wisely the teacher should list the facts, interests, ideals, abilities, processes and principles which are to be developed during the progress of the course. These major items of subject matter will necessitate the introduction of certain additional supporting informational, factual and theoretical subject matter. By reviewing frequently the contents on basis of absolute necessity, only the essential material will remain.

15. *"Measuring the Results of Teaching."* This skill has a twofold application. First the teacher should plan his questions carefully so that his tests will reveal the power of thinking as well as the quality of knowledge acquired by his students. Second, the teacher may occasionally seek the appraisal of his teaching effectiveness by his students. He may from time to time request them to fill in statements on "Teacher Rating Sheets." These sheets should become the property of the instructor so that he may study and interpret them with a view to self-improvement.

These skills have been enumerated so that the young instructor who wants to improve his teaching ability can plan a reading and study program. He may even organize a small seminar group in which each member would undertake to prepare discussions for developing one or more of these skills and then to lead group discussions on the topics he studied.

It has been frequently stated that an important, if not the most important, function of the teacher is to provide conditions which will enable each student to develop to the fullest extent his natural ability to think. Human beings have been endowed with a brain that possesses the power of solving problems,

that is to think. As recently as in the April 1950 issue of the Journal of Engineering Education, page 417, Dean Hammond again called to our attention that "good teaching is the development of the student's ability to do things for himself." It has been the writer's conviction that the objective—the student's ability to do things for himself—could be definitely achieved only by teaching in such a way that the emphasis is *always on the development of the thinking power of each individual* to the extent of the inherent capacity of the student's brain. If personal references may be pardoned the reader is urged to consult two texts which were so written that the initiative for solving problems, namely, the association of a new situation with past experiences is left largely to the student. These texts are: (1) The Theory of Engineering Drawing with Applications; and (2) Analysis and Design of Steel Structures. The act of thinking should not be left to chance of the development of the student's ability to do things for himself.

Fortunately there are teaching principles and procedures which will enable each person to strengthen his inborn capacity to think. To use and apply these principles and methods the teacher himself must devote serious attention to the full understanding of the science of teaching and to the trained skill of applying this science to the development of the student's ability to think.

Other excellent programs available for the technical development of the young instructors are well known and long established. One plan is to take advanced work under the stimulating guidance of capable engineering teachers. These graduate studies lead to the established Master's Degree and the Doctor of Philosophy Degree. Another program involves the pursuit of research in the teacher's field of special interest and ability.

A word of caution is needed at this point. Graduates study and research are of proven value to develop the mature thinking and the advanced knowledge of a person, but only when his teachers stress the strengthening of the person's capacity to think. Furthermore it is expecting too much of graduate study and research programs to imply that these disciplines automatically develop in a person and understanding of the science of teaching and the skill to apply this science in developing the thinking power of the individual. Fortunately, the Creator made man so that he naturally grows in his power to think. If this were not so, the body of knowledge and achievement of the human race would not be where it is today. However, the effective and good teacher provides the intellectual stimulus and scientific background whereby his students definitely and progressively develop their thinking technique.

There is a science and method for designing bridges, generators, jet turbines and airplanes. Men no longer build these engineering creations by guess; they build them by basic science and proven processes. Therefore, the young instructor who aspires to become an effective teacher will master the science of education and the methods of applying this science to the development of the individual's ability to think and, then, to do things for himself.

Becoming a Leader of Men

The engineering teacher is in a unique position to become a leader of men, an inspiration to his students. In fact, he must become a leader of men so that his students may acquire, through direct contact, those qualities which will make their services desired by their professional associates and by the citizens in their communities.

Engineering is one of the newest professions. Engineering education in this country has hardly reached its one hundred and fiftieth anniversay. Yet, today, it is among the foremost in vitality, progressiveness and importance. For example, the daily activities of the farmer are frequently dependent upon the work of the engineer. The farmer receives

energy from extensive rural electrification systems, he operates his farm with many varieties of power driven equipment, and he maintains his contact with adjoining cities by transportation facilities offered by automobiles, trucks and good roads. In a similar manner, comfortable and healthy living conditions in our cities, especially the larger ones, are made possible by the works of the engineer who is responsible for the abundant supply of good water, for the removal and purification of used water, and for the construction of rapid transit systems and structures to meet many needs. Both on the farm and in the cities people can communicate conveniently and effectively by telegram, telephone, radio and television. Since the works of the engineer influence modern life at so many points of contact he should actively concern himself with the problems of his community. It is little wonder, then, that engineering education is proving to be the "general education" for fitting into one's environment and for work in many professions. Society is recognizing that a person with an engineering education acquires discipline in careful, accurate and thorough work and in the systematic and scientific method of basing conclusions on practicality, controlling conditions and verifiable facts.

The engineering teacher who prepares and adheres to a program of becoming a good engineer and an effective teacher possesses excellent opportunity for becoming a leader. For the young man who consciously thinks in terms of service to his students, to his profession and to his community, the educational environment offers an effective medium for the development of leadership. Teaching and the development of leadership, are, or should be, synonymous. By the very nature of his work the engineering teacher tends to deal with the improvement and advancement of the art and science of engineering.

In his daily relations with different groups of students he tends to stress the importance of engineering technology and science in the thinking and activity of his community. He is not completely absorbed in the solution of engineering problems but he is intensely involved in dealing with human beings. He is not satisfied in transmitting only the "know-how" of the profession. He emphasizes "know why, when and where." He is on the alert to learn about or contribute to new improvements in methods, procedure, application and theory. He does not have at his disposal the weekly or monthly paycheck for motivation of his students. He must rely entirely upon his teaching skill to spur young men to high achievement in technical proficiency, personal effectiveness and community responsibility. As a leader, the teacher should think and act in such a manner that his knowledge is respected, his counsel is sought, his judgment is accepted, his requests are fulfilled, his proposals are put into action and his integrity is unquestioned.

In the early years of his teaching experience the young instructor has more freedom to exercise judgment in initiative than that afforded to young men starting to practice engineering. Society affiliations, committee memberships and research activities provide for professional growth. Class room contacts and other faculty responsibilities provide for growth in handling men and for establishing good public relationships. Other outlets for the skill of the young instructor are participation on committees, commissions and boards of the local government and voluntary citizen groups. At first this participation will be modest but on the basis of satisfactory performance the degree of responsibility assigned will grow in proportion to the service rendered by the young instructor.

The self-planned program for the young instructor will provide for his professional growth, for his advancement in the applications of the skills and science of teaching, and for his participation in community affairs. The success of this pro-

gram depends entirely upon the determination, consistency, and judgment with which the young instructor applies himself. The head of his department and the administrative officers of his institution will be pleased to observe and will gladly support his initiative in preparing himself to become a good engineer, an effective teacher, and an active participant in the worth-while programs of his community, be it the home town, the state or the nation.

Cooperative Education Division

Mid-Winter Meeting

By C. E. WATSON

Chairman, Department of Industrial Relations, Northwestern University

The Cooperative Education Division of the ASEE held its mid-winter meeting on the beautiful campus of the University of Florida in Gainesville, Florida, January 9–10, 1951. The sessions were particularly informative, last minute insertions being made in the agenda to cover current problems and the place of cooperative colleges in the national emergency.

A significant paper, entitled "What Type of Training Should Industry Provide for Cooperative Engineering Students?" was given by Mr. Thomas Hand, Acting Head of the Research Department, Corhart Refractories Company, a cooperative student himself in the not-too-distant past. Other men from industry who spoke in support of their individual co-op training programs and outlined their various techniques and points of view included Mr. J. S. Gracy, Vice President of the Florida Power Corporation, Mr. W. E. Gift, Assistant Supervisor of Personnel, Tennessee Eastman Corporation, and Mr. Gordon L. Robertson, Supervisor of Training, Alabama Power Company, who stressed "The Co-op Viewpoint."

Mr. Joseph Hilsenrath, who has been a staunch supporter of cooperative training in the National Bureau of Standards, gave an interesting review of "Cooperative Students and the Civil Service System."

Some of the problems of starting a Cooperative Education program from scratch were covered by Dr. Homer D. Fetty of Los Angeles State College who has been doing just that. An extensive survey conducted by Dr. Fetty indicates that West Coast employers are overwhelmingly enthusiastic about Co-op and are willing to lend their support.

"Interviewing Techniques as Applied to Specific Co-op Procedures" was the topic of a talk by Mr. W. E. Nightingale of Northeastern University containing many timely tips for Coordinators.

Mr. C. J. Riedy, University of Detroit, mentioned a statement once made by Dean Sherwood of M. I. T. that "We had better adjourn before someone brings up the subject of report writing" and then proceeded to cover the topic, "Work Reports—A Student Training Aid" in fine fashion.

Before heading back to the land of snow and ice, the Cooperative Division voted to accept the invitation extended by Prof. C. E. Watson on behalf of Northwestern University to hold the next mid-winter meeting on the Northwestern Campus in Evanston, Illinois. This will be one of a number of significant meetings to be held at Northwestern in celebration of this illustrious University's Centennial year.

Safety Integration Procedures*

By S. S. STEINBERG

Dean, College of Engineering, University of Maryland and Chairman, Committee on Education, President Truman's Conference on Industrial Safety

As a result of recommendations made by the Committee on Education of the President's Conference on Industrial Safety at its meeting in Washington last June, the University of Maryland offered the use of its College of Engineering for an experimental endeavor to determine a practical method of integrating safety into the engineering curricula. The Bureau of Labor Standards, U. S. Department of Labor, was requested to cooperate in this project.

The initial conferences revealed that it would not be feasible to integrate safety into all the existing engineering courses at this time. Therefore, for this first experimental year, integration activities were limited to the Mechanical Engineering curriculum, out of which 16 courses were selected as best suited to integrate accident prevention. The experience gained in the selected courses of the Mechanical Engineering curriculum will be utilized to develop integration material later for the other engineering departments.

Freshman Year

It was felt that sometime during the freshman year the prospective engineer should become acquainted with the accident problem and its magnitude in this country. It was suggested that a practicing safety engineer address the freshmen concerning these problems in the freshman course in Introduction to Engineering, and at the same time point out the safety responsibilities and duties of professional engineers. Also, during the freshman year, safety will be integrated into the English courses, namely, Composition and Literature. This integration will take the form of themes relating to safety and will be coordinated with the current work of the freshman classes in English. Safety will also be integrated into the Public Speaking course for freshmen. This integration will follow the pattern of the work done in the Composition and Literature courses. We are fortunate at the University of Maryland in having departments in English and in Speech which are readily willing to cooperate in our proposals.

Sophomore Year

The integration procedure used for the sophomore year is an attempt to bring safety to the functional level. This was done by inserting material in the texts used for shop work. These insertions are given to the shop instructors to fit into their outlines as they deem best. In addition, sufficient material was developed to aid the instructor in integrating safety into the actual practice work done in the shops.

Manufacturing processes, which is a vital part of the Mechanical Engineering sophomore year, was chosen as an ideal course for safety integration, as the student engineer at this time first becomes familiar with the various methods of manufacturing. In this instance, a supplement was written to the text used, and the instructor will incorporate this ma-

* Presented at the National Conference on Safety Education by Colleges and Universities, Cincinnati, Ohio, November 19–21, 1950.

terial in his present outline. In addition, many references were given to nationally accepted standards with the expectation that the student engineer would also familiarize himself with this material.

Junior Year

The courses in the junior year of the Mechanical Engineering curriculum are basically theoretical in nature and little of the laboratory work permits of safety integration. The only possibility in this year is occasionally to provide a lecture with supplementary reading material so as to keep the student conscious of the safety problem as it will affect him in his future relations with industry.

Senior Year

The integration procedure for the senior year was through the medium of specific insertions in the rather specialized courses. Refrigeration and Air Conditioning, Design of Machine Elements, and Mechanical Engineering Practice, are examples of the more specialized courses for which specific insertions were made. It was felt that integration should be by textbook insertion, and also by supplementary material. Here again the student engineer is expected to familiarize himself with those standards which are applicable to the particular course of study.

This brief resume gives a general idea of the safety integration procedures used by the University of Maryland. It is our present thinking that integration into engineering is the proper approach since it builds the safety factor into specific courses, and causes the student engineer to think of production, efficiency, and safety simultaneously. This attitude somewhat parallels the phrase that "safety and production should go hand in hand" rather than be separated. What we hope for eventually is that in the future revisions of engineering textbooks, we may have safety procedures incorporated into the instruction material.

It would be difficult to evaluate mathematically the importance of our efforts in promoting safety education in the training of our future professional engineers. We must realize that the men we are training in our engineering colleges today will be the industrial leaders of the future, and their consciousness of safety should have a tremendous beneficial influence on the reduction of industrial accidents.

You Will Want To
Reserve This Date.....

JUNE 25-29, 1951

Annual Meeting

Michigan
State
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Promotional System Variables for Engineering Faculties*

By HARRY W. CASE

Associate Professor of Engineering and Psychology, University of California, Los Angeles

Recognizing the pitfalls and sources of error in the "scientific method" of employee evaluation, many college administrators have shown extreme caution in applying evaluatory techniques in appraising their faculties. Expanding student enrollments, with equivalent growth of academic, non-academic, and research employees in engineering colleges, have however increased the need for adequate information on existent promotional policies in engineering schools. Information compiled in this survey on current promotional practices may prove of benefit to administrators.

Questionnaires were sent to universities, state colleges, colleges, and technical institutes, in care of their respective deans as indicated by the Directory of the American Society for Engineering Education. Replies were received from fifty-three universities, twenty-six colleges and state colleges, and ten technical institutes, all of whom had a curriculum in engineering.

The questions and the percentages of replies received are shown in Table 1. In each instance the percentages indicate the proportion of the total of that type institution which replied to the question. The percentages indicated for each question do not equal 100 per cent because of omissions of various questions by different schools. Questions 6, 10, 13, and 14 are not included in this table because the nature of the questions does not lend itself to percentage compilation. Tables 2, 3, and 4 present graphically questions 6, 13, and 14, respectively.

Question 10 which read: "If a written evaluation system is used, please list the qualities evaluated, such as:

a. Teaching ability
b. Attitude, etc.

OR, PREFERABLY, ATTACH A SAMPLE COPY OF THE RATING SHEET."—

was not compiled into tabular form since no technical institutes and only five of the colleges replied listing factors or enclosing a sample rating form. Four universities sent copies of their formal rating sheet, while seven listed qualities used in the written evaluation system. In schools sending copies of their evaluation system, there was little similarity in the mechanics of the systems used. They ranged in type from a linear continuum, with provision made to place a point on a line indicating the degree of the quality possessed, to a simple alphabetical system in which a descriptive phrase of the quality was associated with a letter ranking. One of the scales used a simple numerical system, and still another used a straight subjective essay covering each of the points on which the individual was being evaluated. In terms of complexity they varied from a simple rating scale with very little explanatory material to a complex and detailed scale, accompanied

* Presented at a meeting of the Educational Methods Division at the ASEE Annual Meeting, Seattle, Washington, June 22, 1950.

TABLE 1

ANSWERS TO QUESTIONS 1 THROUGH 5, 7 THROUGH 9, 11, 12, AND 15

TABLE 1

ANSWERS TO QUESTIONS 1 THROUGH 5, 7 THROUGH 9, 11, 12, AND 15

The percentages indicate the proportion of the answers received from the specific type institution. Various institutions omitted various questions.

Questions	Universities		Colleges and State Colleges		Technical Institutes	
	Yes	No	Yes	No	Yes	No
1. Does your university have a standard promotional procedure?	34%	53%	35%	54%	50%	50%
a. For academic personnel?	36%	30%	38%	19%	30%	10%
b. For non-academic personnel? (Excluding research)	15%	45%	31%	23%	10%	30%
c. For personnel engaged solely in research?	15%	42%	12%	34%	10%	20%
2. If your university does have a standard promotional procedure, is it in effect in the College of Engineering?	34%	—	42%	8%	30%	—
a. For academic personnel?	34%	—	42%	4%	30%	—
b. For non-academic personnel?	15%	13%	31%	11%	10%	20%
c. For personnel engaged solely in research?	13%	9%	12%	23%	10%	10%
3. If your university does not have a standard promotional procedure, does the College of Engineering have one?	4%	45%	12%	45%	10%	50%
a. For academic personnel?	—	24%	12%	11%	—	10%
b. For non-academic personnel?	—	24%	—	15%	—	10%
c. For personnel engaged solely in research?	—	24%	4%	19%	—	10%
4. Is this promotional procedure administered by:						
a. An administrative officer in the university?	26%	8%	23%	4%	20%	—
b. An administrative officer of the College of Engineering?	21%	9%	27%	—	10%	—
c. By a committee?	11%	15%	4%	11%	10%	—
d. By a committee making recommendations which are acted upon by an administrative officer?	19%	11%	15%	12%	10%	10%
5. If you use a committee, is it composed of:						
a. Joint membership of Engineering and other academic departments?	11%	13%	12%	3%	10%	—
b. Solely membership of College of Engineering?	6%	13%	12%	3%	—	—
c. Solely Engineering Department membership?	8%	16%	4%	4%	—	—
d. Solely other academic membership?	2%	17%	4%	4%	—	—

TABLE 1—*Continued*

Questions	Universities		Colleges and State Colleges		Technical Institutes	
	Yes	No	Yes	No	Yes	No
7. In ascertaining the eligibility of an individual for promotion, what type of written evidence is accepted?						
a. Publications?	58%	6%	35%	11%	30%	—
b. Written recommendations?	43%	14%	50%	12%	30%	—
c. Some form of rating evaluation?	23%	20%	23%	15%	20%	20%
8. If an evaluation system is used, is it?						
a. A method of rating individuals from best to poorest by overall ability? I.e., 1. Scott—best; 2. Jones—next best; 3. Smith—next best.	9%	25%	4%	15%	10%	10%
b. A rating system in which the individual is placed on a continuum or scale? I.e., rated on certain qualities and the totals obtained?	11%	21%	12%	11%	10%	—
c. A short written description of his activities is prepared or written statements made to certain questions?	23%	13%	27%	8%	10%	—
9. If an evaluation system is used, does it result in:						
a. A score for the individual?	8%	24%	8%	15%	10%	—
b. A letter grade?	—	26%	—	19%	—	—
c. A series of marked descriptions?	8%	20%	—	19%	10%	—
d. A written statement?	23%	13%	27%	8%	—	—
11. Are the faculty required to utilize an analysis of their teaching:						
a. Filled out by themselves?	2%	51%	—	57%	—	10%
b. Filled out by the students?	13%	45%	15%	54%	20%	—
c. Filled out by an administrator?	13%	44%	—	54%	10%	10%
12. Are the results of the evaluation made known to the faculty member?	13%	30%	23%	15%	20%	10%
15. Do promotions within the Engineering Department occur:						
a. More frequently than in other academic departments?	6%	30%	12%	23%	10%	20%
b. Less frequently than in other academic departments?	2%	26%	—	19%	—	20%
c. Approximately the same as in other academic departments?	70%	2%	62%	—	40%	—

TABLE 2

6. In recommending promotions, the factors taken into consideration are: (Indicate percentage of total.)

	Universities												Colleges and State Colleges								Tech. Inst.
	A	B*	B†	C	D	E	F	G	H	I	J	K	A	B	C	D	E	F	G	H	A
a. Teaching ability	25			35	30–45	70	70		25	50	15	52	50					50	20		60
b. Teaching load	5			5					15	25			10								
Sub-Total	30	50	30	40	30–45	70	70	65	40	75	15	52	60	50	25	60	50	50	20	70	60
c. Research ability	5			15	5– 5	5	5		10	5	5	8	15						10		5
d. Research load	5			3		5						8									
e. Research publications				7	15–15		5			5	10	8									
Sub-Total	10	15	15	25	20–20	10	10		10	10	15	24	15			5	20		10	5	5
f. Development ability				1					5		5	2						25	10		10
g. Development load				1					5			2									
h. Development publications				3																	
Sub-Total	5	10	15	5				5	10		5					5		25	10		10
i. Administrative ability	5			3	15– 0	5			5		5	2							10		
j. Administrative load	10			1					5		5	2							5		
k. Administrative publications				1																	
Sub-Total	15		7½	5	15– 0	5		20	10		10	4		20	5	5			15		
l. Committee ability	15			3	5– 5					5	5	2									5
m. Committee load	5			1						5		2									
n. Committee publications				1					↓												
Sub-Total	20	10	7½	5	5– 5				5	10	5	4			10	10				5	5
o. Student counseling and guidance ability	10			2		5	10		4		5	2						15	10		10
p. Student counseling and guidance load				1					3			2									
q. Students' reports on counseling and guidance				2					3		5										
Sub-Total	10			5		5	10	5	10		10	4		20	10	5		15	10	15	10
r. Public service ability				1	5– 5				5		5	2						10	10		
s. Public service load				4					5			2									
Sub-Total				5	5– 5				10		5	4		10	10		10	10	10		
t. Writings—texts				5						5	5	2				5					5
u. Writings—research publications				4							10	2									5
v. Writings—other			↓	1	↓	↓			↓												
Sub-Total			10	10	10–10			5	5	5	15	4			15	5	20		10	5	10
w. Other	10	15	15		15–15	10	10				20		25		25				15		
Total												11								8	1
Percentage of returned questionnaires												21								31	10

* Junior appointments.
† Senior appointments.
Note: Arrows refer to distribution of sub-total.

by comprehensive instructions, designed to cover many job qualifications of the individual being evaluated. From the limited sample it would appear that the scales developed for evaluation purposes in the universities and colleges have a surface validity comparing favorably with those used in private industry.

Schools which listed the qualities shown on their evaluation forms, but failed to enclose an evaluation sheet, included the following factors:

Teaching ability
Personality
Use to the institution
Academic training
Experience
Supervision exercised
Public service
Interest in students in school

TABLE 3

13. At what time intervals are the faculty members evaluated?

PERCENTAGE OF RETURNED QUESTIONAIRES

Time Intervals	Universities	Colleges and State Colleges	Technical Institutes
Twice a year		4	
Yearly	36	54	60
Two years	2		
Three years		4	
Irregular	11	4	
Continuously	4		

Responsibility for methods and policy
Responsibility for records, reports, and schedules
Responsibility for machinery, equipment, and safety
Responsibility for public relations
Responsibility for non-academic duties and committee work
Professional activity outside of classroom
Ability and activity in research
Acceptance by students and colleagues
Attitude
Writings
Student counseling ability
Administrative ability
Professional standards
Laboratory ability.

The factors utilized in the evaluation systems of different institutions differ greatly. However, six institutions listed teaching ability, five attitude, four personality, and two research ability. The remaining factors occurred only once in each of the listings.

Table 2 (in which the specific weights assigned promotional factors are indicated for twelve universities, eight colleges, and one technical institute) emphasizes the difference of opinion existing as to the importance assigned to various tasks in the determination of promotions. It is interesting that the institutions answering this question assigned weights ranging from 15 to 75% to the general area related to teaching in determining promotions in the universities, while the range was from 20 to 70% for the colleges and state colleges. Unlike the popular conception that research is the sole criterion, the weight assigned ranged from 10 to 25% for the universities and from 5 to 20% for the colleges. Seventeen institutions reported they had no specific percentages but considered all the factors listed, while others stated that they had not determined percentages but considered specific items. Of eleven schools which answered the question but said they used no specific percentage, *teaching ability* was listed eleven times; *research ability* nine; *research load* eight; *student counseling and guidance ability* seven; *administrative ability* six; *committee ability* five; *research publications, writings—texts,* and *writings—research publications* four each; *teaching load,* and *writings—other* three each; *development ability,*

TABLE 4

14. What is the usual length of time elapsing between promotion from one academic rank to the next?

PERCENTAGE OF RETURNED QUESTIONNAIRES

Yearly Intervals	Universities	Colleges and State Colleges	Technical Institutes
1– 5	2		
2– 3		4	
2– 5	2		
2–10	2		
3	6	4	
3– 4	2		
3– 5	4	4	10
3– 6	2	8	
3– 7	2		
3– 8	2		
3–10	4		
4	2	4	
4– 5		15	
4– 6			10
4–10	2		
5	2	4	
5– 6			10
5– 7			10
5– 8	2		
5–10		4	10
Irregular	30	23	10

committee load, and *public service ability* two each; and *reports from students* and *other* one each. Nine wrote in their covering letter that they did not believe in any system which considered specific factors or assigned weights to specific areas, but preferred to judge the individual on the basis of his "merit", but unfortunately they did not indicate how this was determined.

Table 3 tabulates the percentages of replies received to the question: "At what time intervals are faculty members evaluated?" While yearly evaluation of the faculty member is the most common, a surprisingly large number of universities (11) and colleges (4) indicated that they had no fixed time interval for evaluation. This may be reflected in one of the replies which read in part: "Practically all the promotions that I have seen since my stay here have been more or less accidental and not due to any plan."

Question 14, "What is the usual length of time elapsing between promotion from one academic rank to another?", is tabulated in Table 4. The poor wording of the question, which did not allow for a sliding time period for promotion from different ranks, is no doubt partly responsible for the fairly wide ranges indicated by some of the schools furnishing data. The explanations that accompanied many of the returned questionnaires indicated that in some instances a three-year period was observed for promotions from one rank to the next for all academic grades, while in other instances the time elapsing was greater if the individual being promoted was of a higher rank. In one case the reverse was true and the longest elapsed time was from instructor to assistant professor. Almost half of the institutions appear to have no formal or customary length of elapsed time between promotions.

An examination of the questions tabulated in Table 1 reveals certain trends. With the exception of the technical institutes, less than half of the institutions replying have a standard promotional procedure, and the chances of an institution's having one for research personnel is less than for academic personnel.

Question 2 seems to show that if the university has a standard promotional procedure, it is also used in the college of engineering for engineering academic personnel. Other personnel do not appear to fare quite so well. In relatively few instances is the college of engineering pioneering in the field of promotional procedures, for the percentages shown in the answers to question 3 indicate that if the university does not have a standard promotional procedure, the engineering college has not attempted to institute one.

The answers to question 4 show that the promotional procedure is administered by an administrative officer of the university or of the college of engineering, and to a much lesser degree by the action of a committee, although in a fairly large number of cases a committee makes recommendations which are acted on by an administrative officer.

When a committee system for promotion is used, it would appear common practice to have the committee formed of members selected from engineering and other academic departments. Surprisingly enough 2% indicated that the committee was entirely composed of members of departments other than engineering.

Question 7 reveals that while publications are the most common type of accepted promotional evidence, written recommendations are also heavily favored, and approximately one-fifth to one-fourth of the schools accept some form of rating evaluation. Question 8 indicates that although the short written statement is used in many institutions, the rating continuum is acceptable, and in some instances the method of absolute ranking is followed. In terms of the evaluation system it appears that the most common form is the type which results in a written statement. A series of marked descriptions and a score for the individual remains in second order of frequency.

Roughly 26% of the universities re-

Technical Institutes
10
10
10
10
10
10

plying to the questionnaire require the faculty to utilize an analysis of their teaching, either filled out by an administrator or by the students.

Finally, question 15 shows that in the majority of instances promotions occur within the engineering department in approximately the same time sequence as in other departments.

Many helpful replies were received in the form of letters that accompanied the returned questionnaire. It is unfortunate that they must be treated as confidential. In general it may be said that the reception to the questionnaire ranged all the way from indignation on the part of some of the smaller institutions, who appeared to be irritated at what they felt was a suggestion that they needed a system for promotions, to outright request for copies of the data as soon as it could be compiled. Many institutions were in the process of investigating the promotional policy with a view toward attempting to correct many of the evils which appeared to have existed in the past. One thing that stood out clearly was that there is relatively little current knowledge concerning the factors or the systems in use in other institutions.

ANNUAL MEETING

MICHIGAN STATE COLLEGE

June 25-29, 1951

EAST LANSING, MICHIGAN

Experience Credit Toward the Professional Engineer's License for Technical Institute Study*

By HAROLD P. RODES

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Stimulated in 1929 by the Wickenden report on engineering education, which included a major section on technical institute training, the tie between professional engineering and the technical institute type of engineering education has been becoming gradually closer and more friendly. Some of the tangible evidences of this relationship are the establishment of the Technical Institute Division of the American Society for Engineering Education and the Subcommittee on Technical Institutes of the Engineers' Council for Professional Development. Just as the medical profession, for example, recognizes that its effectiveness is due partially to the quality of its nurses and medical assistants, so does the engineering profession now recognize in the main that its effectiveness is due partially to the quality of its technicians and engineering aides.

We know, of course, that this improved relationship is not free from areas of irritation to the engineer and the technician, both in industry and in education. Some of the basic problems which remain to be solved include the lack of agreement on terminology, the difficulties encountered in the transfer of technical institute graduates into a professional engineering curriculum, and the establishment of a general policy concerning the granting of experience credit for technical institute training toward the professional engineer's license. For the purposes of this discussion we shall limit ourselves to the last of these problem areas.

Results of Survey of State Policies

Several months ago Dean L. M. K. Boelter requested the Executive Secretary of the National Council of State Boards of Engineering Examiners to undertake a survey of the practices employed in the various states with respect to the granting of experience credit for training of technical institute type. Accordingly, each member state was asked to indicate whether or not it gives experience credit for training received in ECPD accredited technical institute curricula.

The replies were extremely interesting for several reasons. They indicated not only a wide variation in practice from one state to another, but in several cases a complete lack of understanding of the question.

A tabulation of the replies received to date shows that six of the thirty-two states replying grant full experience credit toward a professional engineer's license for ECPD accredited technical institute training; seven states grant no credit; six states grant partial credit; the boards of five states have not yet decided upon a policy for granting credit; five states answered the question as relating to ECPD accredited "engineering" curricula; and three states frankly admitted that they did not understand the question.

* Presented before the Annual Meeting of the Pacific Southwest Section of the American Society for Engineering Education at the University of Southern California, December 28, 1950.

If the states replying with an unequivocal answer can be taken as an adequate sampling, it would appear that the boards in approximately one-fourth of the states are granting full experience credit for ECPD accredited technical institute training toward the professional engineer's license; that about one-fourth are granting no credit whatsoever; that another fourth are granting partial credit; and that in the final fourth the state boards have not yet considered the problem. However, in addition to this last fourth it is apparent that many other states have made their decisions in this matter tentative and subject to change on the basis of additional evidence and argument.

Although it is not the purpose of this paper to launch a crusade for complete standardization in the acceptance of experience credit for technical institute training, I do believe that it is somewhat embarrassing and difficult for the engineering profession to explain why the licensing boards in some states grant full credit while the boards in other states grant no credit for ECPD accredited technical institute training.

Before describing the policy which, in my opinion, represents the most rational and realistic approach to this problem, it might be well to review briefly some of the arguments which have been advanced by the two extremes mentioned previously. The state boards which grant full credit have proceeded on the assumption that two years of technical institute training is the equivalent of two years of engineering training insofar as professional preparation is concerned, an assumption that is questionable in the minds of many. The opposite point of view can perhaps be best presented by quoting the reply received from a member of one of the state boards:

"This matter has not as yet come before the Kentucky Board, but I think I can safely say that we will not give experience credit for work in technical institutes. Having sat in on a number of meetings of ECPD when this situation was discussed I can further say that ECPD certainly does not consider attendance at technical institutes, even though accredited, as having anything to do with registration as a Professional Engineer. I think the reason that ECPD has undertaken this work at all was because they have felt that something of the sort should be done in order to insure a supply of competent technicians but they do not expect the technical institutes to be considered as training Professional Engineers. The two things are entirely separate and distinct."

Like many other issues, this one also has two sides. Each of us probably has an opinion on this particular issue which may be quite close to one side or the other. I suspect, however, that the majority of us, as well as of the state licensing boards, will eventually agree that the ultimate solution lies somewhere between the two extremes.

California Plan

Of the several plans for granting partial credit, I believe that the "California Plan" has the greatest promise. In Section 409 of the California Administrative Code, the State Board of Registration for Civil and Professional Engineers was granted the authority to (1) "give partial credit for the completion of an approved curriculum of technical institute type," and (2) "accept the technical institute type curricula which have been approved by the Engineers' Council for Professional Development."

In order to implement the above legal authorization, the California Board adopted the following resolution: "Moved by Mr. Sullivan, seconded by Mr. Sorensen, that graduates from a technical institute curriculum accredited by the Engineers' Council for Professional Development be given one year's credit toward experience. . . . Motion carried." *

Stated differently, this resolution means that accredited technical institute train-

* Minutes of the California Board of Registration for Civil and Professional Engineers, May 17, 1949.

ing, which is normally of about two years in duration, is considered to be the equivalent of about one year of professional engineering training. An examination of ECPD accredited technical institute curricula indicates that such an evaluation is not far from the actual fact. For example, one accredited technical institute curriculum in the State of California includes courses in Applied Mathematics through Calculus, Aircraft Drafting and Detail Design, Applied Mechanics, Engineering Shop, Technical Report Writing, Elementary Physics, Aerodynamics, and Stress Analysis. Although the objective, and therefore the content of these courses differs considerably from that of the four and five year ECPD accredited engineering curricula, experience has shown that the graduate of such a curriculum who indicates aptitude for professional engineering training can probably complete a four year professional curriculum in about three years. Thus, the decision by the California State Board to grant one year of experience credit for the completion of approximately two years of ECPD accredited technical institute training appears to be a realistic and practical one.

There are undoubtedly those, even in this state, who feel that the Board should not grant any credit, or that it should grant full credit for ECPD accredited technical institute training. There are others who feel that the Board should not restrict the granting of partial credit to those curricula which have been accredited by ECPD. I believe we would all agree, however, that unless certain standards are maintained the licensing of professional engineers is meaningless. Possibly ECPD accreditation is not the only or even the best method of maintaining sufficiently high standards for purposes of registration. Nevertheless, until some of the closely related problems such as terminology and transfer are solved, ECPD accreditation appears to be the only sound educational basis for the granting of experience credit toward the professional engineer's license.

At the present time there are only two institutions in the State of California which are offering technical institute curricula that would qualify for partial experience credit. Even if this number should be greatly increased by the accreditation of technical institute curricula in other private and public institutions, the total number of technical institute graduates applying for professional registration will never be very large. Nevertheless, if the engineering profession is to maintain its current development in a true professional sense, and at the same time avoid some of the errors and inconsistencies which have been plaguing certain other professions, it appears desirable and even essential that the "California Plan" for the granting of experience credit for technical institute training should be continued in this state and considered in some appropriate form in other states.

A Modified Sequence in Teaching Mechanics of Materials*

By E. P. POPOV

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Introduction

Four years ago, after ten years of engineering practice, I returned to academic life and became immediately associated with the teaching of Mechanics of Materials. As is known to all of us, at that time the major segment of the student population was composed of war veterans. Also, as we all know, this group of students was unusually eager to learn conscientiously the subjects of the prescribed curriculum. Yet this determined hard-working group of students appeared to have some basic difficulties in mastering certain portions of our introductory course in Mechanics of Materials. What was the trouble?

Frankly, at first I attributed these difficulties to my being out of touch with academic work. However, after offering the course several times and expending considerable effort on improving my teaching techniques, certain defects in students' learning persisted. During this time an excellent text, widely adopted in this country, was being used. Thus the search for another source of the difficulty started in my mind.

After some deliberation, I attributed many of the difficulties in students' learning of Mechanics of Materials to the sequence in which we taught the subject and in this paper I shall concentrate on this aspect of the problem.

The Basic Methods in Mechanics of Materials

Every subject has a definite technique of its own which must be applied in solving its problems. For example, in applied mathematics, the formulation of differential equation based on considerations of an infinitesimal element dominates the picture. Thence the problem reduce to manipulation for solving these differential equations subject to the prescribed boundary conditions. Precisely the same kind of problems occur in the mathematical Theories of Elasticity and Plasticity. However, the same procedure do not apply to Mechanics of Materials or Technical Elasticity.

The dominant technique employed in Mechanics of Materials consists of passing a section through a body in equilibrium, finding a system of statically equivalent forces required to maintain the portion of the body in equilibrium at the section and finally, with the aid of established formulae, finding the stresses or deformations. This process is repeated over and over in the usual first course of Mechanics of Materials. Yet in teaching, as in many texts, this procedure does not stand out clearly.

A Plan for Revision

Postulating that anything can be mastered by an intelligent student if it is repeated often enough, it occurred to me that unknowingly this principle is frequently violated in teaching Mechanics

* Presented before the Mechanics Division at the 58th Annual Meeting of the ASEE, Seattle, Wash., June 21, 1950.

Materials. In nearly every text-book of Mechanics of Materials used in America, in the beginning of the course students' attention is directed in quick succession to several different concepts of the subject. Thus, along with the study of the effect of axial forces on members, statistically indeterminate problems usually are introduced. With rare exceptions, exposition of riveted joints follows. Then frequently torsion is treated, followed by shear and moment diagrams, the latter preceding the Theory of Flexure. In such a sequence of topics the thread of continuity is broken several times. An opportunity for emphasis and mastery of the basic method of approach is lost. Before a student masters even one fundamental concept, he is already studying the next.

I do not claim to have a complete solution to remedy the above situation; the speed with which we cover the material is an important factor. However for the same coverage, an improvement in the existing situation can be obtained. An alternate sequence of presenting the subject offers a definite advantage.

The necessary modifications in the sequence of teaching Mechanics of Materials seem almost self evident. Statically indeterminate problems, which in a first course on Mechanics of Materials are analyzed on the basis of deformations, should come after the student has had as much experience as possible in computing deformation of members. Likewise, the topic on riveted joints, while not difficult, is based on so many assumptions that it too can be treated more adequately in the later portion of the course. A thorough treatment of shear and moment diagrams early in the course diverts attention from the fundamental method of sections used in Mechanics of Materials.

With great care, the foregoing ideas were incorporated into a revised sequence of assignments in two of our sections of about fifty students each in 1948. We continued to use the same text as before. Another instructor and I taught the sections with the revised sequence of topics and the results appeared to be highly encouraging. In the fall of 1948 our findings were reported to all faculty members who were teaching Mechanics of Materials with a suggestion to try the new scheme on a voluntary basis. Our hand was strengthened by the appearance of two newly published books using a somewhat similar arrangement of topics, indicating that others also were not completely satisfied with the status quo. At that time a majority of the instructors agreed to use the new sequence. Last semester all instructors in Mechanics of Materials followed the revised sequence of topics in teaching this course. As the semesters passed by, revisions were introduced into the program. Now, I believe, a rather effective and distinctive program has evolved.

Present Sequence of Topics

The course is started by giving the students a bird's eye view of the subject with particular emphasis being placed on the forces that are necessary to maintain equilibrium at any section of a member. At such a section the forces are interpreted as an axial force, a torque, a bending moment and a shear. As a detailed investigation of the effect of these forces on material can not be discussed all at once, the students are told that these forces will be examined one at a time in the order named. If only one of these forces is necessary to maintain equilibrium as a section, a solution follows directly. However, if several such forces are present, their effect is investigated individually and the results are superposed.

From the above it is seen that in the beginning we attack the problem of stress and strain distribution at *a* section. Attention is confined to statically determinate cases. As usual, first the axially loaded members are analyzed by cutting a section through the member and finding the force necessary to maintain equilibrium, and stresses are determined. This is followed with torsional problems where again the torque necessary for equilibrium

is found at a section, and stress analysis follows. Then, with a mere mention of shear and moment diagrams, the flexural theory of beams is studied. This again is accomplished by cutting sections and determining the bending moments and shears. After this, superposition of direct and flexual stresses at a section are considered. Here again the method of sectioning is employed. This is followed by situations where shearing, flexural, torsional and axial forces exist at a section simultaneously. This completes the study of stresses on the section. Mohr's circle and failure theories then are introduced.

All of the above topics are extremely similar. In every instance reactions are computed first, a section is passed through the body, strain distribution is assumed and the stresses computed. Much reiteration is possible. Each one of these topics strengthens the one treated earlier and prepares the groundwork for the next one. We find that the students have no difficulty in remembering the few formulae encountered in this work.

Critical sections for axial and torsional members, as well as their deformations are treated simultaneously with the above.

After this portion of the course is completed, the emphasis shifts to design. Pressure vessels are discussed. The students already have an appreciation of the principal stresses at this point of the course, which is highly desirable. Next, various beams are designed by extending the previous investigations to many sections, i.e., shear and moment diagrams are utilized. Much drill in constructing these diagrams is given. While shear and moment diagrams are studied, students are already prepared to design beams, which now require negligible expenditure of time. Knowledge of principal stresses is also very valuable for complete comprehension of the problem.

Beam deflection problems are treated next, first rather lightly by the "double integration" method, and then very intensely by the moment-area method. The moment area method in this sequence finds itself in close proximity to the study of shear and moment diagrams.

After completing the study of beam deflections in our first course on Mechanics of Materials, we introduce statically indeterminate problems. The same philosophy is applicable to all of these problems and all types of these problems are handled simultaneously. At this time the students have a much better appreciation of deformations. They are able to attack the indeterminate problems with much greater confidence. Only problems indeterminate to the first degree are considered in our first course.

We conclude the course with work on columns and a discussion of riveted connections.

Conclusions

Although we use a standard text and must jump around in it a great deal in order to follow this sequence, the results are very satisfactory. The sequence of topics appears logical to the students and from my own experience I know that at the end of a semester they can solve much more difficult problems than they could formerly. On comparable examinations, the average percentage grade has increased 10 to 20%. In addition, as a by-product of this system, many of us find that the students' knowledge of statics is also improved.

We at California are convinced of the merits of this new sequence of teaching the subject. I heartily recommend trying it in your own classes. However, before attempting such an undertaking, be sure that you are completely permeated with the philosophy of this scheme. Also some care must be taken in assigning problems from the usual texts.

Acknowledgments

No innovation of the character discussed above can succeed without support from one's own colleagues. I had such support from numerous men of our fac

ulty. Professors C. T. Wiskocil and H. D. Eberhart encouraged the trial. Professor J. W. Kelly nodded approval, while the younger members of the staff gave it a real try. Among these Professors B. Bresler, R. W. Clough, T. Y. Lin, Messrs. G. W. Brown, F. N. Finn, R. Green, J. H. Jones, A. Olitt, D. Pirtz, K. S. Pister, M. Polivka, A. Scordelis and J. W. Shupe contributed much advice and enthusiastic support for which I am deeply grateful.

Thermodynamics Summer School

June 28–July 7, 1951, Michigan State College

A Summer School in Thermodynamics will be held at Michigan State College, East Lansing, Michigan, June 28–July 7, 1951, at the close of the Annual Meeting of the ASEE. Methods of better teaching of the elementary thermodynamics will be presented as well as modern developments in the field of thermodynamics and a little on advanced theory. In addition, more background material for the teacher will be provided.

The following is a tentative program: June 28, "Leading the Student of Thermodynamics to Think," "Teaching the Concept of State Properties, Boundaries, Systems, etc."; June 29, "First Law of Thermodynamics," "Effective Presentation and Modern Approach to the Second Law of Thermodynamics," "Energy Transfer from the Laws of Thermodynamics," "Fluid Mechanics and Thermodynamics"; June 30, "Availability and Reversibility," "Mathematical Approach to Kinetic Theory of Gases," "Kinetic Theory of Gases and Thermodynamics"; July 2, "Basic Physical Chemistry for Thermo Teachers," "Physical Chemistry and the 1st and 2nd Law of Thermo," "Integration of the Physical Chemistry Approach to Thermodynamics"; July 3, "Visual Aids in Teaching Thermodynamics," "The Atomic Age: How to Equip Engineering Students for It," "Thermodynamics of Gasoline Engine Cycles"; July 4, "Thermodynamics of Vapors: Preparation of Vapor Tables"; July 5, "Combustion Theory: Combustion in Stationary Boilers," "Steam Turbines and Power Plant Design"; July 6, "Theory of Jet Engines," "Combustion in Jet Engines"; July 7, "Gas Turbine Design," "Compressor Design," "Compressor Flow."

A registration fee of $10 will be charged.

On Sanitary Engineering Education

By GEORGE W. REID

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The scope of the field of sanitary engineering has broadened to such an extent that a re-evaluation of the educational requirements has become essential. The older idea that sanitary engineering included only the fields of water supply, sewage disposal, and stream pollution made the planning of a good curriculum relatively simple. A basic engineering course of study, preferably civil or chemical, with electives in the three fields referred to above, was considered adequate and could be accomplished in the regular four-year undergraduate program. Today, many other activities have been added, including vector control, sanitation, housing, milk and food, and air pollution. To this list should be added the newly developing field of health-physics. The list continues to grow as environmental health problems attract engineering services, and the planning of a satisfactory curriculum has become quite difficult.

Educational Studies

Sanitary engineering curriculum planning has concerned educators and public health officials for the past twenty-five years. Their interest has become increasingly intense in recent years paralleling the horizontal expansion of the sanitary engineer's activities. Mendelsohn and Miller (1)(2)(3) in 1924, 1929, and 1939 reported on the current practices in sanitary engineering and traced its expansion to numbers of schools of engineering and public health. With the advent of World War II, sanitary engineering was taught in engineering schools as an offshoot of civil engineering and in public health schools as public health engineering (4). According to the American Public Health Association report, thirty-nine engineering schools and eight public health schools were following this procedure. The earlier water and sewage sanitary engineering taught in civil engineering departments was resisting incorporation of the broader engineering activities of the sanitary engineer, while the public health schools were developing curricula for engineers to be utilized in environmental sanitation. A serious cleavage developed between these two groups and, for that matter, a residual still exists, though much has been done to shorten the gap between these two schools of thought. This is shown by the Straup report (5) in 1945, which indicates a broadening of engineering curricula, and Ingram report (6).

Since the war a great deal of study has been accomplished, including an excellent report by the Sanitary Engineering Committee of the ASEE (7). The general emphasis in this curricula study developed into a five-year program with a division of opinion whether or not the fifth year should be professional work or that the entire program should be integrated through the five years and that recruiting of students should be developed at the freshman level. Reid (8), Wolman, and Geyer (9) preferred a professional year, while Gotaas (10) and Howland (12) preferred full integration. Several new basic ideas were introduced

into sanitary engineering education, including training of all engineers in sanitary engineering ("Preventive Medicine") by Reid (14)(15) and addition of field training to the curriculum as envisioned by Sheppard, Tisdale, and Reid (16)(17)(18)(19). Industrial hygiene was integrated into sanitary engineering curriculum by Reid at Georgia Tech. (20), and health-physics was presented by Reid and Moeller (21) to the ASEE in 1949. Ingram (23) developed a comprehensive program of training evaluation from the study of career sanitary engineers.

Sanitary Engineer

The term "Sanitary Engineering" was defined by the Committee on Sanitary Engineering of the National Research Council, October, 1943, as:

The professional occupational title "Sanitary Engineer" shall apply to a graduate of a full four-year, or longer, course leading to a bachelor's, or higher, degree at a college or university of recognized standing with major study in engineering, who has fitted himself by suitable specialized training, study, and experience (a) to conceive, design, direct, and manage engineering works and projects developed, as a whole, or in part, for the protection and promotion of the public health, and (b) to investigate and correct engineering works and projects that are capable of injury to the public health by being or becoming faulty in conception, design, direction or management. The practice of Sanitary Engineering includes the following activities: (a) Surveys, reports, designs, direction, management and investigation of:

(1) Waterworks or sewerage systems and closely related engineering structures.
(2) Projects relating to stream pollution, insect and vermin control or eradication, rural and camp sanitation, housing sanitation, and milk and food sanitation.
(3) Systems for the prevention of atmospheric pollution or the control of indoor air, especially the air of working spaces in industrial establishments (industrial hygiene engineering).

(b) Professional research and laboratory work supporting the activities listed in (a).
(c) Responsible teaching of sanitary engineering and closely related subjects in colleges or universities of recognized standing.

Ehlers, Ballard, and Ingram have emphasized the environmental phases (22)(23).

The Sanitary Engineering Committee, Civil Engineering Division, American Society for Engineering Education, in its report of June 22, 1949, suggests the following four classifications of sanitary engineering activities (13):

(1) Design and construction of facilities.
(2) Operation—primarily of water, sewage, and industrial waste disposal plants.
(3) Public Health—including all sanitation controls sponsored, initiated or conducted by public and private agencies.
(4) Industrial Hygiene—specialized operations concerning the engineering control of industrial environment.

Obviously, no one undergraduate course of study can adequately prepare a student in all four branches of the field. Actually the only solution appears to be a reversion to the basic subjects and disciplines with a de-emphasis on vocational training.

Basic Curricula

A sanitary engineer's education should prepare him for the wide scope of his field by giving him a proper background for work in design, construction, plant operation, sanitation, industrial hygiene,

etc. His education, therefore, should include basic engineering subjects, including mathematics, surveying, structures, fluid mechanics, geology, soil mechanics, elements of electrical and mechanical engineering. Some knowledge of engineering economics, law, contracts and specifications, and public administration, is valuable to an engineer, and should be included as separate courses or incorporated into other courses. Instruction in statistical methods and biostatistics is necessary in a sanitary engineering curriculum.

In addition to these subjects of value to all engineers, chemistry, bacteriology, and biology are essential subjects in the background education of a sanitary engineer. Some knowledge of P. H. administration, vital statistics, epidemiology, entomology, and parasitology is required.

All engineers should possess, and sanitary engineers must possess, the ability to address a gathering and to express themselves clearly, simply, and precisely, both orally and in writing.

To this basic educational background must be added professional education in water supply, sewerage, industrial wastes, stream pollution, and environmental and industrial sanitation. Every sanitary engineer should have a basic knowledge of all of these and advanced work in his field of specialization.

Three months of field training should be a required part of a sanitary engineering curriculum.

Obviously, it is impossible to crowd all of the desired material into a four-year or even a five-year curriculum without forcing out essential basic subjects. A four-year program leading to a B.S. in engineering appears to be essential and should be followed by a fifth year of study to round out the coverage of the various activities of sanitary engineering. Advanced work should be available in specialized fields. The normal doctoral program may be desired in certain cases, but perhaps a professional degree would be better for most students. The objective of a program leading to this degree would be a higher level of professional competence than is required by the program for the master's degree without the emphasis on creative research which is characteristic of a doctoral program. Such a degree is being offered by the Massachusetts Institute of Technology (24).

A civil engineering background preferably with a sanitary engineering option appears to offer the best coverage of the entire field and is definitely recommended for design and construction activities. A chemical engineering background may be desirable for plant operation and either civil, chemical, or mechanical may be adaptable to the public health and industrial hygiene classifications.

Service courses should be offered to students in other departments to give them some realization of the health hazards which their work might create or eliminate. Reid (14) points out many of these possibilities in his article, "Preventive Medicine."

Seminars should be utilized to develop speaking ability and for training in research methods.

Recent Evaluations

Recommendations and criticisms of the sanitary engineering training as now offered were requested from the state health departments of the forty-eight states and from the main and regional offices of the U. S. Public Health Service. The recommendations were remarkable in their agreement and were essentially those made by Professor Dunstan and his committee (7).

There was an almost unanimous request for a broader coverage of the field with less emphasis on water and sewage and more attention to the other activities. This reaction is natural since the work of the state and federal health agencies is roughly 70% environmental sanitation.

The five-year academic training was considered best by most of the correspondents, the first four years leading to a

B.S. in engineering and the fifth year to an M.S. covering the expanded field. Both the state and federal health services prefer this general coverage in the fifth year to a specialization in any one phase dealing in the general principles of applied sanitary engineering (professional training).

They reason:

(1) Only after the man has started to work can he be sure of the branch to which he will be assigned.
(2) He cannot be sure which he will prefer until he has had some experience.
(3) Specialized education can and will be arranged for when needed.
(4) In any case, a public health officer needs to have at least a speaking knowledge of other phases of public health since one can so readily affect another.

Some knowledge of operating problems was requested instead of all theory. Actual experience, obtained by field training, was high on the list of desired background material.

The criticism most frequently made and most avidly discussed was "inability to speak and write English, to make decent reports and to address gatherings." The success of a public health program will frequently depend upon the ability of the engineer to explain the program to the public and his ability to enlist their support and cooperation. Good public relations are essential.

The academic program as proposed by ASEE is apparently as close to that desired by the state and federal health agencies as can be devised.

Field Training

The need for field training has long been felt. The U.S.P.H.S. operates field training programs for its own personnel and has accepted other students. They now propose to set up training centers throughout the country to offer three-month summer field training to public health and sanitary engineering students (17)(18). The training would be given in cooperation with participating universities and would probably be given between the junior and senior years, replacing the surveying camp now offered in many civil engineering curricula. It should be listed as part of the school curriculum and college credit instructional standards should be obtained. This was done at Georgia Tech. in industrial hygiene cooperatively by Georgia Tech., the State of Georgia, and the United States Public Health Service (19). Such an arrangement will supply the field experience requested, and will offer an opportunity for exchange of ideas among students from many places and with varied backgrounds. A problem in one locality may have been solved already in another.

Seminars

The criticism of the graduate's ability to express himself properly, orally or in writing, is a very common one and one which has been observed in many fields other than sanitary engineering. There is no excuse for lack of good basic engineering "know how," which is essential, but the opportunity to put it to use may be lost because of an inability of the engineer to express himself properly. The student should be given the opportunity to present oral reports frequently enough to develop some poise and the ability to state facts simply and concisely, and to maintain the attention of his audience. This might be accomplished by a greater use of seminars, which would also develop an ability to look up the literature in the field. Far too few graduates can write a clear, brief, and orderly report. Certainly some experience in writing in the third person is essential and can be readily worked into present courses. The student should be impressed with the fact that these things have great practical importance.

Conclusion

A sanitary engineering educational program should consist of:

1. A four-year program leading to a B.S. in engineering. In most cases a sanitary option in C.E. is preferred, although in some instances chemical or mechanical engineering may be desirable. Summer field training should be included (probably in place of surveying camp).

2. A fifth year leading to an M.S. and covering the expanded field.

3. Advanced work in the field of specialization.

Discussions of operational problems should be fitted into both the academic studies and the field training work. Advantage should be taken of all opportunities to develop the students' abilities in public speaking and report writing.

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Summer School
Engineering Drawing Division
June 21-26, 1951

The Executive Board of the ASEE has formally approved sponsorship of the Engineering Drawing Division Summer School to be held in connection with the Annual Meeting at Michigan State College. This will start four days previous to the Society meetings which is Thursday, June 21, 1951, and conclude with our regular sessions allotted during the following week.

The general theme of this school will be "Improving our Status as Teachers of Engineering Drawing" treated on a basis of:

(a) Meeting curriculum requirements
(b) Teaching methods by lecture demonstrations
    1. Basic Drawing
    2. Descriptive Geometry
    3. Advanced Drawing
    4. Elementary and Advanced Graphics
(c) Industrial applications

The local committee at Michigan State College making arrangements at East Lansing for this Summer School consists of Professor C. L. Brattin, Chairman; O. W. Fairbanks; N. R. Sedlander; R. O. Ringoen (all of Michigan State College); Professor Philip O. Potts, University of Michigan; Professor Ralph T. Northrup, Wayne University; and Dean Jasper Gerardi, University of Detroit.

The Division is planning to exhibit student work in engineering drawing, course outlines, foreign drawings, drawing instruments and materials, visual aids and other displays which will be of interest to engineering teachers.

A cordial invitation is extended to all members of the Society who are interested in this program.

RALPH S. PAFFENBARGER, *Chairman*
Division of Engineering Drawing, ASEE
The Ohio State University

The Values Inherent in the Humanities*

By JAMES R. NAIDEN

Assistant Professor of Humanities, University of Washington

The words *values* and *humanities* require a satisfactory definition. Let us begin with the simpler, the Humanities. The term designates a very wide range of subject matter: the study of numerous languages and literatures, such as Latin and Greek, Italian, French, German, English on five continents, including, of course, American literature. Further, the Humanities usually include the subject of the history of art, dealing with the painting, sculpture, and architecture of all eras, places and climates of opinion. To this we may add musicology and musical appreciation, a subject with vast potential appeal, but not so well developed in this country as art history, being perhaps fifty to seventy-five years behind it. These three, literature, art, and music, are the main structure of humanities today. They constitute the productions of men's minds and hands and feelings from the art of the new stone age to the latest poems of Ezra Pound, some eight thousand years by the smallest calculation, and domiciled on four continents chiefly, but in the widest sense resident every place except Antarctica So many tongues, ideas, governments, philosophies, religions, passions and events are reflected in these works of literature, art and music that no human being can possibly peruse and understand more than a fraction of this material. One large university has 113 specialists giving graduate instruction in the various areas described.

From this definition it is clear that our engineering students can never apprehend, in their college years at least, all this subject matter; but that they have acquaintance with some representative parts of it is the desire both of those who are responsible for their education, and of some of the students themselves. This desire for non-scientific knowledge is not present in America alone; in my student days in New York and Paris I knew engineering students from Persia, India, China, Japan, and various countries in Europe, and from them I learned that there is a considerable body of opinion in all those countries that their much more pressing need of technology does not justify, even there, the neglect of art, literature, and music.

Meaning of Value

We now return to the word *value.* A word that covers so much is not easy to define, out of context, with anything like completeness or precision. It is best to proceed by describing the values actually found in the humanities by students of them throughout the world.

The first value that springs to hand is that of pleasure or recreation. Though engineering students are sometimes compelled to acquire a knowledge of these at such a rate as to put stress upon the sterner parts of character rather than upon the aesthetic, the force that produces the literary or artistic work in the first place is *delight.* In a world so troubled as ours, no recreational pursuit needs any defense.

Now what this delight is, is not easy to say. The rhythm of language, of poetry,

* Presented before a meeting of the Humanistic-Social Division Summer School, Seattle, Washington, June 23, 1950.

of music, or of a fresco causes delight, but for what reason seems to be at present beyond the grasp of psychology, or physiology. Let us look at a particular instance. The student of the humanities who meets, for the first time, the Persian miniatures, the Chinese landscape, the thirty-six views of Fujiyama, is likely to be filled with feelings of a mixed sort: of surprise at the coloring, of amusement at the naïveté or freshness of the artist's viewpoint, of speculation at the effectiveness of the strange system of perspective, of sympathy for the vicissitudes of human experience so recorded and so understandable despite a gap of geography and time between the onlooker and the artist. One's delight on looking at larger masterpieces, such as the Pieta of Michelangelo in the Cathedral of Florence, the view of Toledo by El Greco, or the landscapes of Poussin, is different; he here is inwardly cowed by the magnificence of the artist's imagination, by the haunting power of these lines and colors, by the tremendous technique, of which only the last is really easy to analyze.

I have chosen my examples of delight largely from the art of painting, but of course there is equal delight to be found in literature and music. That derived from music is especially difficult to put into words; hence, if we must express in words what value is to be found in the humanities, the area most amenable to our purpose would be literature, the art of words *par excellence*. Here we may observe the effects of rhyme, and rhythm, and the unleashing of the power of association in the reader by the use of famous names. Nowhere in literature is the power of a mere name to excite over powering emotions more clearly told than in the writings of De Quincey, as he relates the panoramas of his opium dreams and that thunderous Latin phrase that gives the whole experience its origin. For simple tastes, the delight of literature may be that of a successful story, of suspense in other words; or of the idealization of character; or of vicarious delight in the way the hero achieves a goal which the reader can only attain through the symbol of literature. For the erudite Latinist, the half-literate reader of detective stories or the illiterate Kashgari tribesman in the mountains of Western Persia, literature is a thriller.

Now some one may say, If literature is so delightful, why does it have to be *taught*? Why do we have to force it down? And one may answer, that these values are not instinctive. One *learns* to appreciate a Persian miniature, a Japanese print, a Spanish painting; the Persian nomad child learns to cry at the sonorous rhythms of the *Shah-nameh* recited beside a campfire by observing the tears running on the faces of his elders. Such appreciation of art, and the manner of expressing appreciation is picked up from the environment, and in our culture, the school is the place where such things are often taught. Households wherein the Persian poets, the Italian painters, the sonnets of Shakespeare, and the writings of Jefferson are not a part of the life, may send their children to the universities or the secondary schools, where the government, inscribing on the first reader the verses, or the image of the great artist in the humanities, acquaints the budding personality with the fact that this poem, painting, or musical phrase is somehow what men take delight and pride in, and must labor to appreciate, preserve, and transmit to oncoming generations. Appreciation of the fine arts is not instinctive; it is part of what the anthropologists call acculturation, the leading of the new life into reasonable conformity with established standards of language, manners, courtship, government, military proficiency, religious orientation, and, what is of concern to us, of appreciation of the recreational art and the way of life as symbolized by such typical humanistic expressions as the music of Germany and Italy, the poetry of Japan and China, the multifarious paintings of Mexico and America. Whether at home, at school, or in the

university, the appreciation of the fine arts must be inculcated, literally, must be taught, directly or indirectly. If mathematics must be taught, humanities must be taught, and in part for the same reason, not merely for uniformity of expression, not even for orthodoxy, but because the humanities are what they are because of an acculturation process going back for ten or twenty thousand years. To participate in this thing, one must labor, study, attend, have emotions, repeat the experience, follow others, until the process is reasonably complete—in other words, one must be educated.

Scope of Humanities

So far we have arrived at this: the humanities are the total of the works of art, literature, and music of the world, and more significantly of human appreciation of them, which appreciation has to be somewhat laboriously acquired through a period of education.

And what is the good of this knowledge and these attitudes if we get them? Are these pleasures any better than those a person without them might have? What good does this knowledge do that the knowledge of social sciences and mathematics and natural sciences would not? What value is there, to repeat the title of this paper, inherent in the humanities that is peculiar to them, and exactly how does it benefit those who attain it?

We have spoken of the delight that one learns to feel from the contagion of our fellows. In the next place, one must place the *immediacy* of the humanities. The artist and the onlooker are in direct, or almost direct communication. In the case of a phonograph record of Frost reading his own poetry, the contact is about as direct as it could be. In the case of the student who approaches the masters of delight through the mediation of a commentator, virtuoso, or editor, the immediate contact between artist and onlooker is supplemented by that of a teacher whose function it is to increase the bonds between artist and onlooker. As an example of immediate contact, the present speaker has looked at the paintings of El Greco, just, or almost just, as they stood when the last brushmark was completed; at the statuary of Michelangelo as he left it; at the Perseus of Cellini just as he made it. The words of Homer, Lucretius, and Milton he has heard approximately as they were originally spoken. With such personal communication from the great of other times, one can do as he pleases. One can, in the proper company, reuse the original phrases to enamel one's own rough expression; one can appropriate the feelings of the sensitive and observant and experienced to one's self. The irreligious can share, for a while, the inner life of the Trappist monk; the unverbalized student can reproduce, as he reads the *Apology,* the unequalled fluency of Plato; the helterskelter mind can temporarily attend to the point with the precision of an Aquinas. Lack of expressive power fetters the young, as we all know; and likewise even the perfect mastery of one language does not begin to suggest the expressiveness and precision of other tongues and cultures.

The perusal of these masters of expression or of word, line, color, or phrase repays in the increased ability to define to one's own self what one wants, and the price one is willing to pay to get it. The self-knowledge of a Socrates adds to the self-knowledge of a twentieth century student of engineering. The self-knowledge of the Chinese landscape painters will teach us a good deal about what one can think about the natural grandeurs of the National Forests thirty miles east of Seattle, and may help to settle in someone's mind just how much social cost it is worth to keep them from a predatory economic environment. The self-knowledge of St. Augustine's *Confessions* may jar the conceit out of some of our sophomores, or out of ourselves, the latter being the case more probable than the former. So thus we may know

ourselves, and be verbally precise about it, after a study of the humanities.

Self-Knowledge and Self-Expression

But in a day of group action such as ours, the educational value put upon subjects devoted to self-knowledge and self-expression is generally less than that put upon those which are conducive to the good of groups. Thus in our day medicine, engineering, economics, and social work are academic areas of great distinction; oriental literature and the classics are in the caretaker stages. One may properly ask, what value have the humanities for the times we live in?

Our times are cosmopolitan. Our universitiy faculties are international as they have not been since Latin ceased to be a universal language. Our plans for national defense embrace a dozen other countries, many of them quite alien to ourselves in heritage and outlook. At the highest level in the government of men, in science, as well as in literature, the lines of communication are international, yes, global. The leaders and the followers of the next generation must not be provincial. Just as the intellectual preeminence of the ancient Greeks over their contemporaries is believed to be the result of their contact with many races and climates of opinion, just so the present preeminence of the English-speaking cultures may rest in part upon the wide and deep contact with foreign cultures, in war, in peace, in the school, in the art museum, in the concert hall, as teachers and students, engineers and experts, travelers and writers. For an international future, an international type of education must surely be one of the foundations.

No more dramatic proof of the value of the humanities for the international world we live in can be cited than the opposition to them by a recently deceased but well-known German politician, and the present rulers of the Communist third of the earth. There is no place for a sympathetic understanding of other times and places, for the personal, individual, sympathetic development that the humanities stand for. The aim of those societies most of us take to be the destruction of the world of differing cultures, and the exaltation of one particular way of life. For the analysis of such nonsense as is solemnly promulgated by these people and for a ready perception of the real dangers, there is no restorative so helpful as a knowledge of the facts of history, art, and literature, with which such grand lunacy may be seen in its real perspective. That a world can be shattered by new ideas, the student of humanities knows from his study of the effect of Christianity upon classical pagan culture. How potent new ideas can be he knows from his reading of Voltaire. That a heroic action can arrest the dynamics of such a movement, he knows, too. That the reaction can prove deadlier than the danger it confronted, he knows from the history of Sparta, and the intellectual silence that brooded over the plains of that automatic country. That all is not lost if the government is lost, he has learned from the Consolations of Boethius. With experience, perspective, and knowledge, the student of humanities is fit for the strenous international contest that lies before us. And in the local arena the humanities will prepare him also. He who has read the poignant *Forty Days of Musa Dagh* and the terrible *Os Sertoes* will have some idea of how *not* to deal with our curious neighbors, the Doukhobors, who carry out the will of God by dynamiting railroad trestles and burning their own houses, to say nothing of stripping naked in the courts of the otherwise conservative province of British Columbia.

For the extension of one's experience beyond one's own lifetime; for the comprehension of other personalities; for the quick acculturation into the life of our friends and enemies, the humanities and the social sciences go hand in hand. The social sciences are concerned in the main with the record of groups; the humani-

ties in the main, with individuals. In a time such as ours, when each one thinks of himself both as a member of groups and as an individual, both subjects are indispensable.

But let me summarize, now, what has been said. The humanities are man's artistic, literary, and musical activities they include the learned patterns of ap preciation to them and they further self knowledge and self-expression, while a the same time furthering our knowledg of and ability to work with or in foreig cultures.

Summer School
Humanistic Social Division
June 21-23, 1951

The Humanistic-Social Division of the ASEE is now making plans for its summer school to be held at Michigan State College in June immediately preceding the regular meetings of the Society. The summer school will be held June 21, 22, and 23rd, and the Divisional meetings of the regular session will be on June 25 and 26. Anyone interested, therefore, can attend both the summer session and the regular Division meetings in a period of six days.

The past two summer schools have been devoted to consideration of the general problems involved in planning, developing, and teaching courses and integrated sequences in the humanities and social sciences to students of science and engineering. All of those who have attended have felt that this interchange of ideas and discussion of common problems has been well worth while, and it is hoped that this year's session will be as valuable as the past two have been.

All members of the Society are cordially invited to attend any or all of the summer school sessions and to participate in the discussions. Anyone who is interested in attending or who has a problem he would like to present is urged to write to Dr. John W. Shirley, North Carolina State College, Raleigh, North Carolina. Further information will be published in the JOURNAL as soon as it is available.

Library Identification with Teaching and Research

Abstract of Report, Executive Committee, Engineering School Libraries Committee, 1950–51

The library as an admitted force in learning, teaching, and research activities is a rare phenomenon in educational institutions concerned with science and technology. The problematical situation of apathy toward library utility in educational institutions devoted to science and technology has prompted certain observations and arguments:

1. Time and efficiency, which are so important to the success of any engineering endeavor, too often are sacrificed where even a small amount of literature-searching skill on the part of the investigators would have saved both.

2. The ability to find information quickly can be an asset of high economic value. Acquired through ordinary powers of analysis, such ability will be found to be of measurable gain from the first year of college through an engineer's entire career.

3. The potentialities of library techniques and resources are seriously overlooked by the studying, the teaching, and the practicing engineer alike.

Believing that no library exists, nor can exist for its own sake, nor in a vacuum, nor as a mere formal requirement, the Engineering School Libraries Committee of the ASEE is undertaking a long-range study of the essentials of vital library service in science and technology. The Committee's statement is intended to indicate the broad lines along which its members are planning to proceed, looking toward common recognition of the library as a dynamic in high-level student learning, in best teaching and in successful research.

To implement its program, the Committee is attempting to develop active Engineering School Libraries groups in all ASEE Sections. Section Chairmen have been asked to assist by appointing Section ESL Committee Chairmen from lists of librarians in their regions. It is suggested that the membership of the Section ESL Committee consist not only of librarians, but also of faculty members in the region. The Section ESL Committee will confine its action to discovering, in its region, what is required of library service to achieve integration with teaching and research, and thereafter develop techniques for implementing such integration. Since these things involve the views and opinions of teachers, ESL meetings must include them and not be conducted as librarians' discussion groups.

In general, librarians in engineering and science school libraries are being urged to identify themselves with the work of the ASEE in all of its ramifications; to accept and seek membership on various ASEE Committees, and in other ways come to know the requirements of teaching and research as expressed by the various Divisions and Committees of the ASEE; and, importantly, to become known as an agent and source of aid in all professional activities of the ASEE and of its individual members.

Restated, the Committee's overall aim is this: to effect recognition of the library as a coordinate agency of education, with as much responsibility and significance in teaching and research as any department of instruction; an objective whose realization depends directly upon acceptance of responsibility by the individual working librarian.

EXECUTIVE COMMITTEE,
ESL Committee, ASEE

Johanna E. Allerding
W. R. Harvey
Philip Leslie
John B. O'Farrell
David A. Webb
Edward A. Chapman, *Chairman*

A New Nomographic Treatment of the Cubic

By C. R. WYLIE, JR.

Chairman, Department of Mathematics and Astronomy, University of Utah

In many engineering problems one of the important details is the numerical solution of a cubic equation. In addition to the exact, but cumbersome, formulas for the roots of such an equation, there are many well known methods of approximate solution, but in spite of this it seems appropriate to call attention to still another. Since the following graphical treatment of the general cubic was first suggested by work in applied differential equations, and probably finds its greatest usefulness in this field we shall develop it from this point of view.

Suppose, then, that we are interested in the linear differential equation with constant coefficients

$$a_0 \frac{d^3z}{dt^3} + a_1 \frac{d^2z}{dt^2} + a_2 \frac{dz}{dt} + a_3 = 0. \quad (1)$$

In the usual problem in dynamics or in governing, the a's will all be positive, but the applicability of our method does not depend upon this fact. As a device to reduce the number of parameters with which we must deal, let us make the proportional change of independent variable

$$t = \left(\frac{a_0}{a_3}\right)^{\frac{1}{3}} T. \quad (2)$$

This reduces the given equation to the simpler, dimensionless form

$$\frac{d^3z}{dT^3} + U \frac{d^2z}{dT^2} + V \frac{dz}{dT} + 1 = 0, \quad (3)$$

where

$$U = \frac{a_1}{a_0}\left(\frac{a_0}{a_3}\right)^{\frac{1}{3}} \text{ and } V = \frac{a_2}{a_0}\left(\frac{a_0}{a_3}\right)^{\frac{1}{3}}.$$

Under the substitution (2) the characteristic equation of (1) is transformed from

$$a_0 s^3 + a_1 s^2 + a_2 s + a_3 = 0 \quad (4)$$

into

$$S^3 + US^2 + VS + 1 = 0. \quad (5)$$

In other words, the change of variable (2) in the differential equation is equivalent to the change of variable

$$s = \left(\frac{a_3}{a_0}\right)^{\frac{1}{3}} S$$

in the characteristic equation. Hence if $S = r$ is a root of (5), then

$$s = \left(\frac{a_3}{a_0}\right)^{\frac{1}{3}} r \quad (6)$$

is a root of (4).

It is worth noting that the coefficients U and V can be computed from the original coefficients a_0, a_1, a_2, a_3, by a simple slide rule calculation. Hence as a starting point for a practical method of solution, (5) is to be preferred to the more usual reduced form of the cubic

$$S^3 + \alpha S + \beta = 0$$

obtained from (4) by the relatively complicated algebraic process of eliminating the term in s^2 by the substitution

$$s = S - \frac{a_1}{3a_0}.$$

By means of the useful identity

$$A\phi_1 + B\phi_2 + \phi_3 \equiv \begin{vmatrix} A & 1 & 0 \\ B & 0 & 1 \\ \phi_3 & -\phi_1 & -\phi_2 \end{vmatrix}$$

we can write (5) in the form

$$\begin{vmatrix} U & 1 & 0 \\ V & 0 & 1 \\ -(S^3+1) & S^2 & S \end{vmatrix} = 0. \quad (7)$$

Hence the construction of a nomogram from which the real roots of (5) can be read is now hardly more than a routine matter.

However, before we can display (7) as an alignment chart in the ordinary cartesian plane it is necessary that the last column in the determinant consist entirely of 1's. There are of course infinitely many projective transformations which will accomplish this, but if we desire to keep the scales of U and V uniform, as is certainly natural, our choice is severely limited. In fact there are essentially only two possibilities: we may either add the elements of the second column to the corresponding elements in the third column, or we may subtract them. The first alternative leads at once to

$$\begin{vmatrix} U & 1 & 1 \\ V & 0 & 1 \\ -\dfrac{S^2-S+1}{S} & \dfrac{S}{S+1} & 1 \end{vmatrix} = 0. \quad (8.1)$$

The second leads similarly to

$$\begin{vmatrix} U & 1 & 1 \\ -V & 0 & 1 \\ -\dfrac{S^2+1}{S^2-S} & \dfrac{S}{S-1} & 1 \end{vmatrix} = 0. \quad (8.2)$$

In each case U and V are represented by uniform scales on the lines $y = 1$ and $y = 0$, respectively. In (8.1), S is read from a cubic curve graduated according to the parametric representation

$$x = -\frac{S^2-S+1}{S}, \quad y = \frac{S}{S+1}.$$

In (8.2) the scale of S is defined by the parametric equations

$$x = -\frac{S^3+1}{S^2-S}, \quad y = \frac{S}{S-1}.$$

The nomogram corresponding to (8.1) is shown in Fig. 1. Since in most applications, U and V turn out to be small positive numbers, it is evident that the important range $S < 0$ is adequately covered except for values in the neighborhood of $S = -1$. One interesting feature of Fig. 1 which is not strictly a part of the nomogram is the semi-circular arc which partially surrounds the origin. This is the envelop of the lines joining positive values of U and V such that $UV = 1$. Now the stability criteria for the solutions of a differential equation such as (1), i.e., the conditions that each root of the characteristic equation (4) have negative real part, are that all coefficients be positive and that

$$a_1 a_2 > a_0 a_3.$$

Hence it is clear that all roots of (5), including the complex roots not given by the nomogram, will have negative real part when and only when U and V are positive, and when in addition, the line joining U and V does not intersect this arc. If the coefficients a_0 and a_3 are of like sign (so that the roots of (4) have the same sign as the roots of (5)) this ensures that all solutions of (1) are stable.

A nomogram based on (8.2) would have the general appearance of Fig. 2. However, since Fig. 1 adequately represents Equation 5 except around $S = -1$ we have drawn only the portion of this second nomogram shown in Fig. 3. Of course after the roots of (5) have been found from Figs. 1 and 3, (6) gives the roots of the original equation, (4).

In many applications it is unnecessary to know the complete solution of (1), for all that is required is a knowledge of how fast the transients represented by this solution will decay. For the solution corresponding to the real root or roots of (4), this rate of attenuation can be found immediately. However for the oscillatory transient corresponding to a pair of complex roots of (4) the situation is not quite so simple. If the characteristic equation has a pair of complex roots we

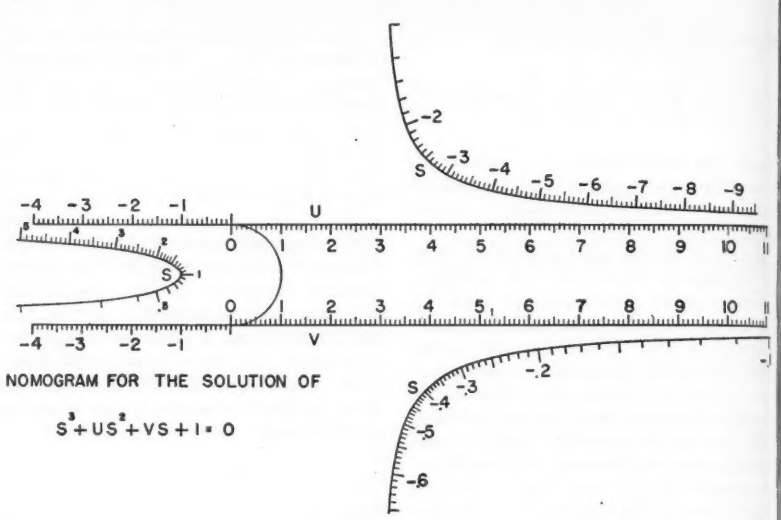

FIG. 1.

can of course solve for them explicitly from the quadratic equation remaining when we divide out the linear factor corresponding to the one known real root. With the complex roots known, the rate of attenuation of the corresponding transient can easily be determined. On the other hand it is probably more convenient to proceed as follows.

Consider the second order differential equation

$$m\ddot{z} + c\dot{z} + kz = 0, \qquad (9)$$

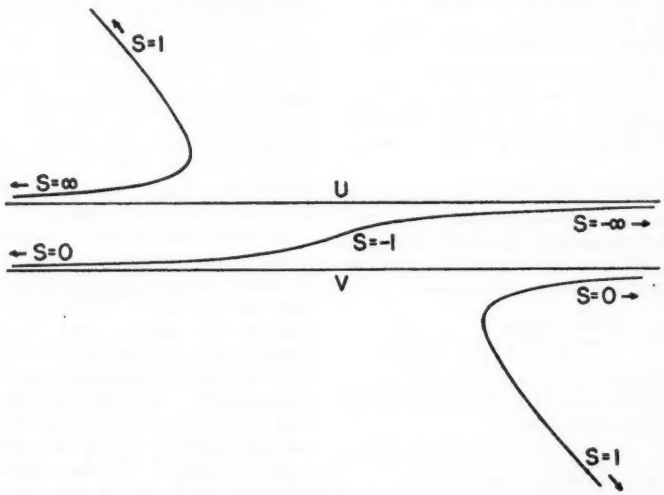

FIG. 2.

whose characteristic equation we suppose to have roots

$$-p \pm iq.$$

The undamped natural frequency of the behavior described by this equation is of course

$$\omega_n = \sqrt{\frac{k}{m}}$$

and the critical damping (or its equivalent) is

$$c_c = 2\sqrt{km}.$$

Hence we can write (9) in the form

$$\ddot{z} + 2\frac{c}{c_c}\omega_n \dot{z} + \omega_n{}^2 z = 0.$$

Comparing this with the equivalent form

$$\ddot{z} + 2p\dot{z} + (p^2 + q^2)\, z = 0$$

it is clear that

$$R \equiv \frac{c}{c_c} = \frac{p}{\omega_n} \text{ and } \omega^2{}_n = p^2 + q^2.$$

Hence the damping ratio, or fraction of critical damping actually present (which is a convenient and conventional measure of the rate at which the solution of (9) will decay) is expressed in terms of the roots of the characteristic equation of (9) through the formula

$$R = \frac{p}{\sqrt{p^2 + q^2}}. \qquad (10)$$

Obviously the foregoing analysis can be applied to any differential equation whose characteristic equation has one or more pair of complex roots, the oscillatory solution corresponding to each pair of complex roots being characterized by its own particular damping ratio, R. Specifically, if the roots of the characteristic equation of (1) are $-p \pm iq$ and $-m$, it is possible to compute the damping ratio of the one oscillatory component without actually finding the complex roots. To show how this can be done, we first observe that if the roots of (4) are $-p \pm iq$ and $-m$, then the roots of (5)

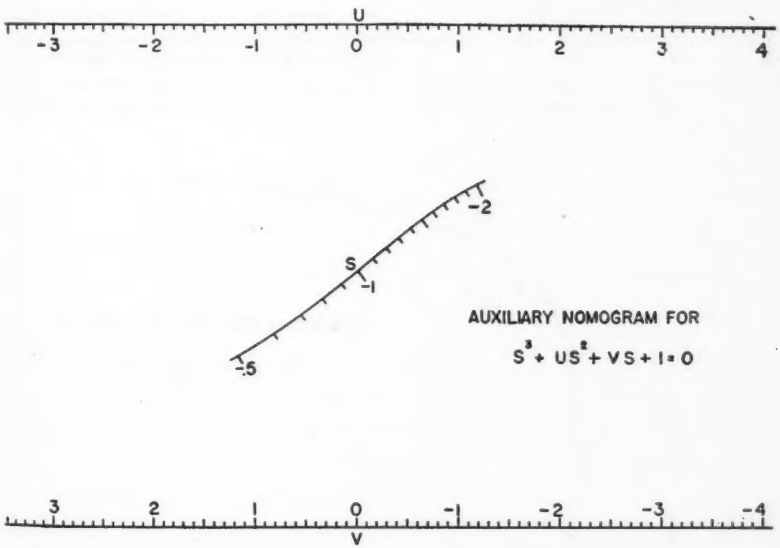

FIG. 3.

are

$$-P \pm iQ = (-p \pm iq)\left(\frac{a_3}{a_0}\right)^{\frac{1}{3}}$$

and

$$-M = -m\left(\frac{a_3}{a_0}\right)^{\frac{1}{3}}.$$

Hence

$$\frac{p}{\sqrt{p^2+q^2}} = \pm\frac{P}{\sqrt{P^2+Q^2}}$$

the plus sign being taken if a_0 and a_3 are of like sign and the negative sign if a_0 and a_3 are of opposite sign. Thus R can be computed equally well from the roots of (4) or from the roots of (5).

Now using the well known relations between the roots and coefficients of a polynomial equation, we have from (5)

$$U = M + 2P, \tag{11}$$

$$V = 2MP + P^2 + Q^2, \tag{12}$$

$$1 = M(P^2 + Q^2). \tag{13}$$

From the first and third of these equations we have

$$P = \frac{U-M}{2} \text{ and } P^2 + Q^2 = \frac{1}{M}$$

and so

$$R = \frac{P}{\sqrt{P^2+Q^2}} = \left(\frac{U-M}{2}\right)\sqrt{M}$$

or

$$U - M - \frac{2R}{\sqrt{M}} = 0. \tag{14}$$

Similarly, eliminating P and $(P^2 + Q^2)$ from (12) by using the relations

$$P = R\sqrt{P^2+Q^2} \text{ and } P^2 + Q^2 = \frac{1}{M}$$

we have

$$V - \frac{1}{M} - 2R\sqrt{M} = 0. \tag{15}$$

Either (14) or (15) furnishes a simple formula for R, provided that the real root, $-M$, is known. Since $-M$ can always be read from Figs. 1 and 3, the damping ratio R can thus be found with-

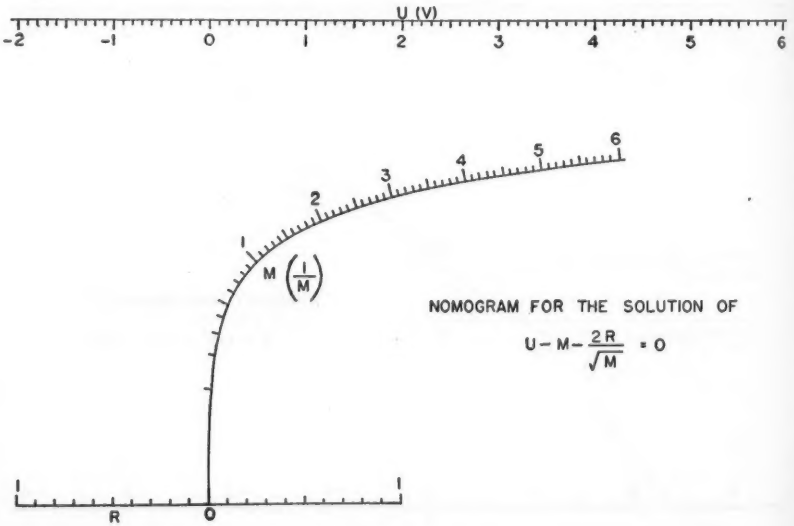

FIG. 4.

out a knowledge of the complex roots, $-P \pm iQ$. To facilitate the calculation of R it is convenient to display Formulas 14 and 15 as nomograms. To do this, we can write (among infinitely many other possibilities)

$$\begin{vmatrix} U & 1 & 1 \\ -2R & 0 & 1 \\ \dfrac{M\sqrt{M}}{\sqrt{M}+1} & \dfrac{\sqrt{M}}{\sqrt{M}+1} & 1 \end{vmatrix} = 0 \quad (16)$$

$$\begin{vmatrix} V & 1 & 1 \\ -2R & 0 & 1 \\ \dfrac{1}{M(1+\sqrt{M})} & \dfrac{1}{1+\sqrt{M}} & 1 \end{vmatrix} = 0. \quad (17)$$

Fig. 4 shows the nomogram representing (16). Two scales are necessary for the variable R because, as pointed out above, the values of R as computed from the roots of (4) and from the roots of (5), while numerically equal, will be of like or unlike sign according as $a_0a_3 > 0$ or $a_0a_3 < 0$. In Fig. 4 the scale of R which extends to the left is to be used if $a_0a_3 > 0$. If $a_0a_3 < 0$ the scale which extends to the right is to be used. Of course if one is solving for R (instead of using R as a datum) one simply reads R from whichever scale the line joining U and M happens to intersect.

We have not drawn the nomogram corresponding to Equation 17 because not only is it superfluous in general, but moreover it is essentially identical with the nomogram of Fig. 4. By comparing Equations 16 and 17, it is clear that the corresponding nomograms are the same except that the U-scale in the former is called the V-scale in the latter, and the scales of M in the two charts are reciprocally graduated. In other words, Fig. 4 can be used as a nomogram for Equation 17 simply by aligning the values of V, on the U-scale, with $\frac{1}{M}$ on the M-scale, and reading R just as before, on the third scale.

It is interesting to note that the value of R determined from Fig. 4 can be used to calculate the complex roots of (5). For from (10) and (13) we have

$$P = \frac{R}{\sqrt{M}} \text{ and } Q = \frac{\sqrt{1-R^2}}{\sqrt{M}}.$$

Hence the complex roots of (5) are simply

$$\frac{-R \pm i\sqrt{1-R^2}}{\sqrt{M}}.$$

The complex roots of (4) can then be found immediately from (6).

Engineering Graphics Fifty Years Hence

J. NORMAN ARNOLD, *Purdue University*

Several incidents are responsible for the odd character of this guest editorial. Among them are:

1. The recent finding in an old trunk of a set of student descriptive geometry plates done at M.I.T. in 1873.
2. As a "visiting" staff member with a foot in each of two schools, figuratively speaking, one has a peculiar feeling of unreality and detachment from both; the fact that the two schools are nearly a thousand miles apart intensifies this feeling. These remarks are one manifestation of this anomalous condition.
3. Divergent trends in graphical instruction at present observable in the two schools inevitably induces speculation on the future.

In the space of a page or two it is not possible exhaustively to analyze the past and carefully to hedge some astounding prognostications regarding the future—though it might be fun to do so. However, a brief summary of some generally recognized past history is pertinent.

One of the general trends in engineering education over the past fifty years has been the gradual increase in the proportion of student time devoted to the study of scientific principles and the corresponding decrease in the proportion of time and credit devoted to manual skills, such as drafting and wood-working. In some schools drawings were almost all done in ink 50 years ago; today very few or none are completed in ink. The plates dated 1873, referred to above, were all inked and included rendered problems in shades and shadows. Block-lettered title pages were a part of this set of plates.

Organizational modifications within an institution have a powerful, but slow-acting influence. Fluid mechanics, as taught at present, is more inclusive and general than "hydraulics" and "properties of gases" which it has partially replaced in the curricula. Blacksmithing instruction of the past has become heat-treating and welding of the present, on a more rational and less empirical foundation. Most of the present well-established branches of engineering instruction are an outgrowth of an older one.

In the light of the foregoing, it seems possible that the next fifty years may see the development of a more coherent, inclusive, and general body of graphical principles. At present, there appears to be a group of somewhat distinct graphical or partially graphical courses of instruction, each of which is a mixture of principles, specific applications, conventional practices, and manual skill instruction.

Uniformity in courses of instruction and uniformity in internal organization of engineering schools is neither desirable nor probable. However, a more integrated body of graphical science might lead to reorganization of some schools, associating all graphical science together in one department. Such organization would not mean the elimination of manual skill or artistic instruction. But in view of the trend toward more principles and less practice in the required courses, it probably would mean that the artistic, conventional practice, and manual skill instruction would be primarily on an elective basis for students interested and gifted along this line.

Vociferous opposition from all sides undoubtedly would assail anyone foolhardy enough to offer a program for reorganizing graphical instruction. It is not in keeping with the detached, philosophical, long-range view inherent in the title to suggest such a program. It may be appropriate to offer one hint of ways in which greater generality of instruction seems possible. Vectors, and vector solutions of problems, are a part of several engineering curricula. Perhaps someone may find a way to make vector principles meaningful and applicable for students of all branches of engineering at the same time.

By way of a closing footnote, the Advanced Graphics Committee of the Drawing Division has, as some of its duties, the collection and analysis of graphical methods in use in all scientific fields and the classification and integration into a consistent pattern of the underlying principles involved.

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Section	*Location of Meeting*	*Dates*	*Chairman of Section*
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Illinois-Indiana	Northwestern University	May 19, 1951	W. C. Knopf, Northwestern University
Kansas-Nebraska	University of Nebraska	Fall, 1951	Kenneth Rose, University of Kansas
Michigan	General Motors Institute, Flint, Michigan	May 5, 1951	H. M. Dent, General Motors Institute
Middle Atlantic	Rutgers University	May 12, 1951	S. J Tracy, Jr., City College of New York
Missouri	University of Missouri	April 7, 1951	R. J. W. Koopman, Washington University
National Capital Area	George Washington University	Feb. 6, 1951	R. B. Allen, University of Maryland
	U. S. Naval Post Graduate School	May 12, 1951	
New England	Rhode Island State College	Oct. 13, 1951	W. C. White, Northeastern University
*North Midwest	University of Minnesota		E. W. Johnson, University of Minnesota
Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Idaho	1951	A. S. Janssen, University of Idaho
Pacific Southwest	University of Nevada	Dec. 27–28, 1951	S. F. Duncan, University of Southern California
Rocky Mountain	Utah State Agricultural College, Logan, Utah	April 13–14, 1951	J. E. Christiansen, Utah State Agricultural College
Southeastern	Buena Vista Hotel, Biloxi, Miss.	March 22, 23, 24, 1951	E. B. Norris, Virginia Polytechnic Institute
*Southwestern	Texas A. & M. College		R. L. Pourifoy, Texas A. & M. College
Upper New York	Clarkson College	Oct. 12–13, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

*No Date Set.

Candid Comments

Engineers in Public Service

Dear Mr. Bronwell:

For a long time I've had on my desk the October 1950 copy of the JOURNAL OF ENGINEERING EDUCATION. There was one article in that which rather rubbed me the wrong way and I've kept the book before me as I thought I might write to you some time and tell you about it. Morris Llewellyn Cooke presented a paper at the 58th annual meeting of ASEE which you have reprinted on page 68 of the October issue. It is titled "The Role of the Engineer in Community Affairs."

In this article Mr. Cooke takes the engineer to task for his failure to do his part in community affairs. To almost all of Mr. Cooke's statements I find myself in disagreement. I do not believe that the engineer is any worse or perhaps even as bad as are other professional groups in this phase of his life. Mr. Cooke says: "With engineers . . . — citizens status is all but ignored." This is far from the truth as I see it. Later on he refers to: "The failure of the engineer and scientist to participate in community affairs." Also at another place he says that: "Only a negligible percentage interest themselves in public affairs."

Naturally I do not know the situation in the United States as well as I do in Canada but even with my slight knowledge of conditions there it strikes me that a great many engineers take leading parts in public affairs. How about W. L. Batt and Senator Flanders and the various senior officers of the American societies who operate the Engineers Joint Council? All these people have taken or are taking very prominent parts in the affairs of the United States.

In Canada I know of no group that shows as much interest in public affairs as do the engineers. Of course it is the lawyers who lead in politics but once you get away from that showy demonstration of service to the community you will find the engineer occupying more posts than anyone else.

In Canada we have several engineers in the federal house of Parliament and on the federal cabinet there are two—in fact the senior member of the cabinet next to the prime minister is an engineer.

As I travel back and forth across Canada visiting at all our branches I find great numbers of engineers who are or who have been mayors of their communities, aldermen, councillors, school trustees, etc. I see them as heads of voluntary organizations such as the service clubs, the Canadian Club, Royal Automobile Society, and from time to time various cultural organizations.

Right now in Montreal the president of the Montreal Board of Trade is J. B. Stirling, an engineer who incidentally is vice-president-elect of the Institute. He tells me that on the board of his organization there are about six engineers. Also at the last count the executive of the Canadian Chamber of Commerce showed that about ten out of sixteen members were engineers.

Some day I must settle down to preparing a list of interests such as this which are followed by engineers so that I will have something ready to throw at such people as Mr. Cooke just as soon as I find them uttering their adverse comments. I'm sure I can make up a very impressive list of Canadians, and I'm equally confident that an equally impressive list could be made up of Americans.

It's time we stopped this useless and unjustified criticism of ourselves. It is all right to urge the engineers to take even a greater part in public affairs but I don't think that this is where you should start, with an adverse criticism as the basis. Let's brag about what we've been doing and then go on to urge that we do more.

Yours sincerely,

L. AUSTIN WRIGHT,
General Secretary,
Engineering Institute of Canada

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